Final Report

**2010 FUTURE YEAR OZONE MODELING
FOR THE DALLAS/FORT WORTH AREA**

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Prepared for

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EXECUTIVE SUMMARY

The 1990 Clean Air Act Amendments authorized the Environmental Protection Agency (EPA) to designate areas failing to meet the National Ambient Air Quality Standard (NAAQS) for ozone as nonattainment and to classify them according to severity. Once an area is declared nonattainment, the state must develop a State Implementation Plan (SIP) to improve the air quality by the attainment deadline. The SIP must contain an attainment demonstration, usually based upon photochemical modeling to show attainment by the deadline.

In 1997, the EPA established a new ozone standard, set at 0.08 parts per million ozone averaged over an 8-hour time frame. New implementation guidance for the 8-hour standard was issued on April 15, 2004. The new guidance classifies nine counties in the DFW area (Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker and Rockwall) as a moderate 8-hour nonattainment area with an attainment date of 2010.

The Texas Commission on Environmental Quality (TCEQ) plans to submit to EPA an "Early Increment of Progress" plan not later than June of 2005 showing a 5% reduction in emissions from a 2002 baseline, effective by June of 2007. Then, a State Implementation Plan (SIP) including an attainment demonstration based on ozone modeling must be developed and submitted to EPA not later than June of 2007 showing attainment of the 8-hour ozone standard by 2010.

The 2010 future year ozone modeling described here used the latest version 4.03 of the CAMx model with revised meteorological data and the most recently available emission inventory projections from the TCEQ to model ozone air quality for the Dallas/Fort Worth (DFW) area using an August 1999 episode. The development of the August 13-22, 1999 episode by ENVIRON for the TCEQ was described previously by Mansell et al., (2003) as updated by Emery et al., (2004). Emery et al., (2004) updated the meteorological data for the August 1999 episode and reevaluated the CAMx model performance. The 2010 future year ozone results described here will be used by the TCEQ in planning activities for the 8-hour ozone standard.

The future year 2010 emission inventory was developed jointly by ENVIRON and TCEQ. The TCEQ developed gridded, model-ready emissions files for area and off-road mobile sources for the entire state of Texas for both the 12-km regional and 4-km DFW emissions grids. On-road mobile source emissions for all areas were based on EPA's MOBILE6 model. Off-road mobile source emissions were based on the 2002 version of EPA's NONROAD model for most source categories. Point source emissions were based on data from TCEQ's point source database (PSDB) and EPA's National Emissions Inventory. Area source emissions for Texas were based on TCEQ data and for other states were based on EPA's data developed for a rulemaking on heavy-duty diesel (HDD) engines. Biogenic emissions were unchanged from the 1999 base case inventory as described by Mansell, et al. (2003). Section 2 of this report details the development of the modeling inventory for the 2010 future year.

All of the meteorological input data for the CAMx simulations were derived from the Fifth Generation Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5; Duhdia, 1993). The MM5 modeling used nested 108-km, 36-km, 12-km and 4-km grids and 28 vertical layers. An analysis of the meteorological modeling for the updated 1999 and 2010 ozone modeling is presented by Emery et al (2004).

The final MM5 run used in the updated 1999 and the 2010 future year CAMx simulations documented herein is called MM5 Run5.

Results of the future year ozone modeling for 2010 are presented in Section 3. Predicted daily maximum 8-hour ozone concentrations are presented in Table 3-2 for the 4-km DFW modeling domain. Broad regions of ozone reductions in 2010 are realized throughout the modeling domain, although some areas of ozone increases due to "NOx disbenefits" are seen in the Dallas urban core. On most episode days, the locations the 8-hour ozone peaks are shifted towards the urban core in 2010 relative to 1999.

The results of the 2010 future year ozone modeling were analyzed using the design value scaling methodology outlined in the EPA's 8-hour draft modeling guidance (EPA, 1999). The design value scaling analysis is presented and discussed in Section 3.

The design value scaling for the 2010 future year can be summarized as follows:

- An analysis was completed for 8-hour ozone levels in 2010 using EPA's design value (DV) scaling methodology.
- The projected 8-hour design values for 2010 exceeded the target level of 84 ppb (after truncation) at 8 of 18 monitor locations in the DFW area.
- The relative reduction factor analysis projected that only four monitors (Dallas C402, Cleburne, Weatherford and Eagle Mt Lake) would come into attainment of the 8-hour ozone standard by 2010.
- The highest projected 8-hour design value for 2010 was 92.4 ppb at the Frisco monitor.
- There were no increases in monitor design values ("NOx disbenefits") between 1999 and 2010.

A series of emission reduction sensitivities for 2010 were considered in order to provide "directional guidance" in developing control measure to address the 8-hour ozone standard. Both NOx and VOC emissions reductions were considered. The reductions were applied within the 9-county DFW area to all anthropogenic emissions as well as to specific source categories. The source category specific reductions removed a constant 40 tons per day from specific source categories and so are called the "40 ton per day" sensitivity tests. The specific emission reduction scenarios and the development of the emission inventories are described in Section 3.

Based on the results of the "across the board" emission reduction sensitivity tests, the following findings are presented:

- NOx controls are more effective than VOC controls in reducing 8-hour ozone at all monitors in the DFW area, although VOC emission reductions do contribute slightly to reducing the 8-hour ozone concentrations.
- About 50% "across the board" NOx reduction in the 9-County area is needed to bring the highest ozone monitor into 8-hour ozone attainment (i.e., below 85 ppb).

- The four monitors that are hardest to bring into 8-hour ozone attainment with “across the board” NOx reductions are Frisco, Midlothian, Dallas CAMS60 and Grapevine.

- There are no “NOx disbenefits” in the responses of 8-hour ozone design values to NOx control, i.e., there are no increases in 8-hour ozone design values resulting from NOx controls.

- The Frisco monitor is the hardest to bring into 8-hour ozone attainment using “across the board” NOx reductions. Frisco is responsive to NOx reductions in the 9-County area but is the hardest monitor to control because it has the highest design value in the 2010 base case.

- Several monitors (i.e., CAMS63 and CAMS60) respond poorly to NOx reductions at about the 20% level, although these monitors respond well to deeper NOx reductions. This poor initial response to NOx reduction is likely due to the proximity of these monitors to areas of “NOx disbenefit” seen between 1999 and 2010 near the Dallas urban core.

- The Midlothian monitor is less responsive to across the board NOx emission reductions in the 9-County area than other monitors and, consequently, is among the hardest to bring into 8-hour ozone attainment. This poor response is likely because the Midlothian monitor is upwind of the majority of the emission reductions on most of the episode days. The standard EPA design value scaling approach may not work well for the Midlothian monitor.

- The emissions reduction scenarios are for region-wide emissions reductions – source-specific reductions might be more or less effective at specific monitor locations.

The following findings are based on the results of the “40 ton per day” emission reduction sensitivity tests presented and discussed in Section 3:

- NOx reductions are more effective than VOC reductions at lowering ozone at all four “hardest to control” monitors (Frisco, CAMS-60, Midlothian and Grapevine).

- NOx reductions from point sources are less effective at lowering ozone than NOx reductions from on-road, off-road or area sources at the Frisco and Grapevine monitor locations.

- NOx reductions from all sources are about equally effective at lowering ozone at the Dallas CAMS60 and Midlothian monitor locations.

- Because there are differences between monitors, control strategy designs can be made more effective by accounting for the specific sources that influence ozone at each monitor.

An ozone source apportionment analysis was completed for the 2010 future case to help understand which geographic areas and categories of emissions contribute to high ozone in the DFW area for the 2010 future case. A discussion of the source apportionment technique and the analysis for the 2010 future year case was presented in Section 4. The source apportionment analyses used a technique called APCA, which stands for Anthropogenic Precursor Culpability Assessment.

The source contributions to 8-hour ozone in the four DFW core counties, presented and discussed in Section 4, can be summarized as follows:

- The contribution of initial conditions is small because of the two spin-up days (August 13-14) while the contribution of boundary conditions is consistent throughout the episode and reaches a daytime peak of ~35 ppb each day.

- The contribution of biogenic emissions is small because APCA is designed to minimize the "non-controllable" contribution from biogenic contributions. The APCA biogenic emissions contributions result from the interaction of biogenic VOC and NOx and so are limited by the biogenic NOx emission levels.

- The contribution of NOx emissions is much greater than VOC emissions indicating that controlling NOx will be the most effective strategy for DFW.

- The small contribution of VOC emissions is greater on the days with highest 8-hour ozone in the core counties (August 16-19) indicating more influence of VOC emissions on the most stagnant days.

- The contribution of NOx emissions to 8-hour ozone in the four core counties is split about evenly between on-road mobile, point sources and area plus off-road (when all source regions are aggregated).

The average contributions to 8-hour ozone above 85 ppb in the four DFW counties are presented in Tables 4-2 to 4-4. The main findings can be summarized as follows:

- The largest emissions contributions to high 8-hour ozone in the DFW 4-county area come from nearby emissions sources.

- The relative importance of different emission source categories varies by region and year. For the 4 DFW core counties, on-road mobile sources and area plus off-road sources are the largest contributors, well ahead of point sources. For the surrounding 11 counties, these three anthropogenic source categories are more comparable with on-road mobile the largest contributor in 1999 and point sources the largest contributor in 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the 4 Counties was 36.5 ppb in 1999 and 28.6 ppb in 2010. The reduction of 7.9 ppb was due to reduced contributions from on-road mobile and point sources offset partially by an increased contribution from area plus off-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the surrounding 11 counties was 4.1 ppb in 1999 and 4.7 ppb in 2010. The 0.6 ppb increase was due mostly to higher contributions from point sources in Ellis County (0.7 ppb increase) and

Kaufman County (0.3 ppb increase). The contribution of on-road sources from the surrounding 11 counties decreased from 1999 to 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from other regions within Texas and the surrounding states varied from by region and emission source category. The contributions to high 8-hour ozone decreased from 1999 to 2010 by approximately 0.1 ppb to 1 ppb per region, depending on the region.

- The contribution to high 8-hour ozone in the DFW 4-county area from other states (i.e., outside of Texas, Louisiana, Arkansas and Oklahoma) was 3.9 ppb in 1999 and 3.3 ppb in 2010.

- The contribution of model boundary conditions to high 8-hour ozone in the DFW 4-county area was about 33 ppb in both 2010 and 1999' while the contribution of model initial conditions to high 8-hour ozone in the DFW 4-county area (after two spin-up days) was less than 1 ppb in both 2010 and 1999.

The APCA results for 2010 were analyzed at monitor locations for use in conjunction with the 2010 "design value scaling." The DV scaling method as applied to DFW monitor locations was described in Section 4 and the results are presented in Figures 4-3 to 4-6 for the four hardest to control monitors (Frisco, Dallas CAMS60, Midlothian and Grapevine, see Section 3 and Figure 3-7). The results of the APCA analysis for the four hardest to control monitors can be summarized as follows:

- Dallas County is the highest contributing source area at three of the four monitors (Frisco, CAMS60 and Grapevine) while Ellis County is the highest contributing source area at the Midlothian monitor.

- Dallas County contributions are dominated by area plus off-road and on-road mobile (NOx) emissions.

- Ellis County contributions are dominated by point source (NOx) emissions.

- Transport from outside the DFW nine county area is relatively more important at Midlothian than the other three monitors.

1.0 INTRODUCTION

This report describes the results of the 2010 future year ozone modeling of the Dallas/Fort Worth (DFW) area using an August 1999 episode. The development of the August 13-22, 1999 episode by ENVIRON for the Texas Commission on Environmental Quality (TCEQ) was described previously by Mansell et al., (2003) and Emery et al., (2004). The 2010 future year ozone results described here will be used by the TCEQ in planning activities for the 8-hour ozone standard.

Background

The 1990 Clean Air Act Amendments authorized the Environmental Protection Agency (EPA) to designate areas failing to meet the National Ambient Air Quality Standard (NAAQS) for ozone as nonattainment and to classify them according to severity. Once an area is declared nonattainment, the state must develop a State Implementation Plan (SIP) to improve the air quality by the attainment deadline. The SIP must contain an attainment demonstration, usually based upon photochemical modeling to show attainment by the deadline.

In 1997, the EPA established a new ozone standard, set at 0.08 parts per million ozone averaged over an 8-hour time frame. New implementation guidance for the 8-hour standard was issued on April 15, 2004. The new guidance classifies nine counties in the DFW area (Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker and Rockwall) as a moderate 8-hour nonattainment area with an attainment date of 2010.

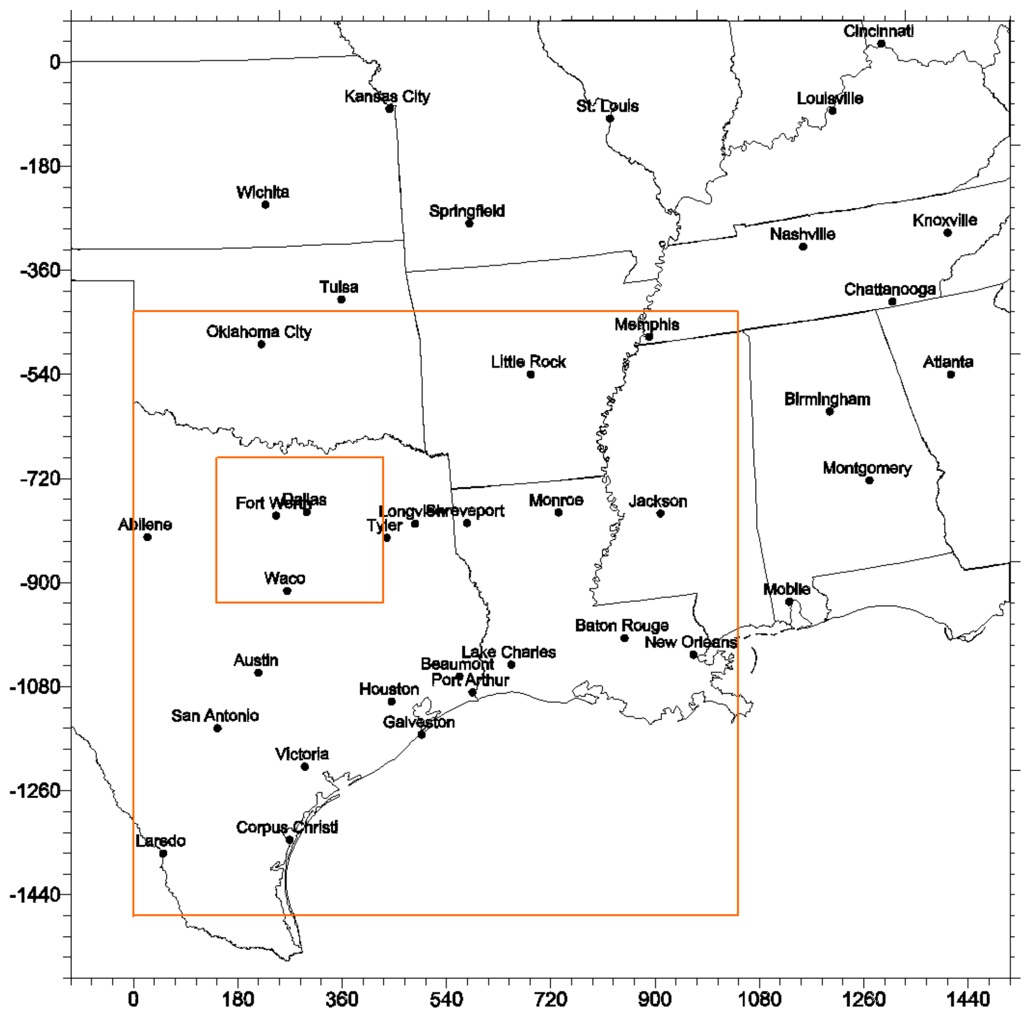
The TCEQ plans to submit to EPA an "Early Increment of Progress" plan not later than June of 2005 showing a 5% reduction in emissions from a 2002 baseline, effective by June of 2007. Then, a State Implementation Plan (SIP) including an attainment demonstration based on ozone modeling must be developed and submitted to EPA not later than June of 2007 showing attainment of the 8-hour ozone standard by 2010.

Basis for the 2010 Modeling

Attainment demonstration modeling for 8-hour ozone uses a “design value scaling” (DV scaling) method described by EPA in the draft 8-hour ozone modeling guidance (EPA, 1999). Briefly, this approach estimates future year ozone DVs by multiplying the historical base year DVs by relative reduction factors (RRFs) determined from photochemical modeling. The important implication is that 8-hour attainment demonstrations use ozone-modeling results in a relative sense rather than relying upon the absolute ozone levels modeled in the future year. Consistency between the base and future year modeling methods is particularly important to 8-hour ozone modeling because the attainment demonstration uses a base/future year comparison.

The 2010 future year ozone modeling described here used the latest version 4.03 of the CAMx model with revised meteorological data and the most recently available emission inventory projections from the TCEQ. The original 1999 base case modeling (run 7c) described by Mansell et al. (2003) used CAMx version 4.02 and different meteorology data. Emery et al., (2004) updated the meteorological data for the August 1999 episode and reevaluated the CAMx model performance. The 2010 modeling results presented here should be compared to the most recent 1999 base case (run 17b) developed by Emery et al. (2004).

The CAMx ozone modeling domain for this study, shown in Figure 1-1, provides a 4-km high-resolution grid in the DFW area nested within 12-km and 36-km grids covering much of the South, Southeast and Central US. This modeling domain was designed to provide high-resolution for all sources in the DFW area and also include all regional sources within a 2-3 day transport time of DFW.



CAMx GRID DIMENSIONS
LCP Grid with reference origin at (40 N, 100 W)

36 km Grid:	45 x 46 cells	from	(-108, -1584)	to	(1512, 72)
12 km Grid:	87 x 87 cells	from	(0, -1476)	to	(1044, -432)
4 km Grid:	72 x 63 cells	from	(144, -936)	to	(432, -684)

(nested grid dimensions do not include buffer cells)

Figure 1-1. CAMx modeling domain for the August 1999 episode showing the 36-km regional grid and the nested 12-km and 4-km fine grids.

2.0 EMISSIONS PROCESSING

The August 13-22, 1999 DFW ozone episode, a Friday through Sunday, is modeled in CAMx using a Lambert Conformal Projection (LCP) nested grid configuration with grid resolutions of 36, 12 and 4-km (Figure 1-1). In CAMx, emissions are separated between surface (surface and low level point) emissions and elevated point source emissions. For the surface emissions, a separate emission inventory is required for each grid nest, i.e., three inventories. For elevated point sources, a single emission inventory is prepared covering all grid nests.

Two emissions modeling domains are used to generate the required CAMx ready inventories:

1. **Dallas/Fort Worth Non-Attainment Area 4-km Grid**. The DFW emissions grid has 72 x 63 cells at 4-km resolution and covers the same area as the CAMx 4-km nested grid shown in Figure 1-1.

2. **Regional Emissions Grid**. Emissions for the CAMx 36-km and 12-km grids are prepared together in a single emissions processing step for efficiency. The regional emissions grid has 135 x 138 cells at 12-km resolution and covers the full area shown in Figure 1-1. This emissions grid is used for the 12-km CAMx grid by "windowing out" emissions for the appropriate region. In contrast, the regional emissions grid is aggregated from nine 12-km cells to one 36-km cell over the entire area to generate the CAMx 36-km grid.

DATA SOURCES FOR 1999

The development of the original emission inventories for the 1999 base year is documented in Mansell et al. (2003). In August of 2004, the 1999 emission inventory was updated to reflect the most recent enhancements to the on-road mobile source category. The TCEQ provided gridded on-road mobile source data files for the entire domain. The updates for the on-mobile source emissions for 1999 are described in Emery et al. (2004). Table 2-1 provides a summary of data sources used in the development of the 1999 inventory. Updated emission summaries for 1999 by source category and county were presented in Emery et al. (2004).

Table 2-1. Summary of emissions data sources for 1999.

Category	Region	Data Source
Mobile	DFW	TCEQ link-based, MOBILE6
	Texas major urban	TTI link-based, MOBILE6 via TCEQ
	Other Texas	TTI county level, MOBILE6 via TCEQ
	Outside Texas	EPA NEI99 Version 3, MOBILE6
Offroad	Texas	NONROAD 2002 model
	DFW	NCTCOG local data and NONROAD 2002 model
	Outside Texas	EPA NEI99 Version 2
Area	Texas	TCEQ
	Outside Texas	EPA NEI99 Version 2
Point	TX and LA EGU	EPA acid rain hourly data processed by TCEQ
	Texas other	1999 PSDB
	Louisiana other	LA DEQ provided to TCEQ
	OK EGU	EPA acid rain hourly data processed by ENVIRON
	OK other	EPA NEI99 Version 2 with ODEQ corrections
	Other	EPA NEI99 Version 2
Offshore	Texas	TCEQ offshore and shipping emissions
Biogenic	DFW	GloBEIS3.1 with TCEQ LULC data
	Outside DFW	GloBEIS2.2 with TCEQ and BELD3 LULC data

DATA SOURCES FOR 2010

The future year 2010 emission inventory was developed jointly by ENVIRON and TCEQ. The TCEQ developed gridded, model-ready emissions files for area and off-road mobile sources for the entire state of Texas for both the 12-km regional and 4-km DFW emissions grids. On-road mobile source emissions for all areas were based on EPA's MOBILE6 model. Off-road mobile source emissions were based on the 2002 version of EPA's NONROAD model for most source categories. Point source emissions were based on data from TCEQ's point source database (PSDB) and EPA's National Emissions Inventory. Area source emissions for Texas were based on TCEQ data and for other states were based on EPA's data developed for a rulemaking on heavy-duty diesel (HDD) engines. Biogenic emissions were unchanged from the 1999 base case inventory as described by Mansell, et al. (2003).

The data sources for the 2010 emissions inventories are described in more detail below followed by summary tables of gridded emissions by county and source category. Spatial plots of the 2010 NOx, VOC and CO emissions by source category for the August 17 episode day are presented for the 12-km and 4-km grids.

On-Road Mobile Sources

All on-road mobile source emissions were based on EPA's MOBILE6 model. The DFW area 2010 vehicle miles traveled (VMT) were from future case travel demand modeling. Control measures for on-road mobile sources were modeled using MOBILE6. On-road mobile source emissions were developed by TCEQ using MOBILE6.2. The modeling files were downloaded from TCEQ's FTP server:
ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/DFWAQSE/Modeling/EI/Mobile/2010/eps2x
The following files were provided:

- gridded.m62.2010.df_2km.tar
- gridded.m62.2010.df_4km.tar
- gridded.m62.2010.df_12km.tar
- gridded.m62.2010.hg_12km.tar
- gridded.m62.2010.bp_12km.tar
- gridded.m62.2010.tx_12km.tar
- gridded.m62.2010.us_12km.tar

DFW: On-road mobile source link-based emissions were developed by TCEQ using MOBILE6.2. The DFW on-road mobile emissions are based on a 7-day week using 2010 vehicle miles traveled (VMT) and fleet turnover with day-specific adjustments for temperature and humidity.

Rest of Texas: County-level emissions from MOBILE6 for 4 day of week scenarios (average weekday, Friday, Saturday and Sunday) and 2010 VMT and fleet turnover developed by TTI with day-specific adjustments for temperature and humidity.

Other States: MOBILE6.2 county level emissions for typical summer day conditions (as used in the NEI999v2) with EPA data for 2010 VMT and fleet turnover.

Off-Road Mobile Sources

Off-road mobile source emissions for all categories except aircraft, commercial marine and locomotives were from EPA's 2002 version of the NONROAD model (NONROADv2002). The TCEQ developed the NONROAD model input data for Texas and EPA data was used elsewhere. Emissions for aircraft, commercial marine and locomotives are not included in NONROAD and so were estimated by TCEQ and EPA for 1999 and projected to 2010 using EPA data including the Economic Growth Analysis System (EGAS).

Texas: TCEQ provided gridded model-ready off-road mobile source emissions data. The modeling files were downloaded from TCEQ's anonymous FTP server:

- ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/dfw_04km_areaNR
- ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/reg_12km_areaNR

Other States: NONROADv2002 with EPA default input data for 2010. Aircraft, commercial marine and railroad emissions for 2010 were developed by EPA as part of rulemaking on "heavy duty diesel" emissions.

Area Sources

Emissions for stationary sources that are not individually inventoried (area sources) were based on data developed for 2002 by TCEQ and EPA. Emissions for years later than 2002 were projected using EGAS and other data.

Texas: TCEQ provided gridded model-ready area source emissions data. The modeling files were downloaded from TCEQ's FTP server:
ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/dfw_04km_areaNR
ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/reg_12km_areaNR

Other States: EPA 2007 emission inventory developed for a rulemaking on "heavy duty diesel" emissions.

Point Sources

Emissions for individual stationary point sources were based on data from TCEQ, EPA and the Louisiana DEQ (LDEQ). The TCEQ provided model-ready point source emissions data for the entire modeling domain. Gridded low-level point source emission files were provided for both the 12-km regional and 4-km DFW modeling domains. The data were downloaded from TCEQ's FTP server:
ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/point

The following files were provided:

- dfw_2010_pts.tar.gz

Biogenic Emissions

The biogenic emissions were unchanged from the 1999 base case, as documented in Mansell, et al. (2003). The development of the biogenic emissions data is discussed below for completeness. Biogenic emissions were prepared using both versions 2.2 and 3.1 of the GloBEIS model (Yarwood et al., 1999a,b). The GloBEIS model was developed by the National Center for Atmospheric Research and ENVIRON under sponsorship from the TCEQ. Two versions of the GloBEIS model were used in order to take advantage of the various enhanced features available in GloBEIS version 3.1 for the DFW 4-km modeling domain. Regional biogenic emissions were developed using GloBEIS version 2.2.

GloBEIS Version 2.2

GloBEIS version 2.2 was based on the EPA BEIS2 model algorithms with the following improvements:

- Updated emission factor algorithm (called the BEIS99 algorithm).
- Compatible with the EPA's Biogenic Emission Landcover Database – Version 3 (BELD-3).
- Compatible with the TCEQ's Texas specific landcover database which includes local surveys of DFW vegetation (Yarwood et al., 1999b).
- Ability to directly input solar radiation data for photosynthetically active radiation (PAR).

GloBEIS 2.2 requires input data for landuse/landcover (LULC), temperature and solar radiation. The TCEQ provided these data for the August 1999 episode period (Yarwood et al., 2001). Briefly, these data were:

- TCEQ LULC data for Texas and Mexico.
- EPA BELD-3 LULC data for all other U.S. States.
- Hourly temperature data from interpolated NWS observations.
- Hourly solar radiation (PAR) based on GOES satellite data as analyzed by the University of Maryland.

GloBEIS Version 3.1

GloBEIS, version 3.1, was released in 2002 (Guenther et al., 2002) and has the following changes from version 2.2:

- Options to model the impacts of drought and prolonged periods of high temperature.
- Optional leaf energy balance model.
- Optional direct input of leaf area index (e.g., from satellite data).
- Option to model effects of leaf age on emissions (seasonal effects).
- Chemical speciation for the SAPRC99 and CB4 mechanisms.
- Updated speciation of other VOC emissions.
- GloBEIS3 emission factor model (previously called BEIS99).

GloBEIS3.1 and GloBEIS2.2 calculations result in the same emissions when using the same input data. Using the options to model drought impacts and prolonged periods of high temperature requires input data for humidity and wind speed in addition to temperature. It is important for these humidity and temperature inputs to be consistent (e.g., from a meteorological model such as MM5).

Biogenic Inventory Preparation

GloBEIS was used to calculate day specific, gridded, speciated, hourly emissions of biogenic VOCs and NOx for each modeling grid (36-km, 12-km, 4-km). The model versions and input data were as follows.

DFW 4-km grid area: Biogenic emissions were calculated using GloBEIS3.1 with TCEQ LULC data, MM5 temperature data and GOES satellite PAR data.

Texas outside of the DFW 4-km grid area: Biogenic emissions were calculated using GloBEIS2.2 with TCEQ LULC data, interpolated observed temperature data and GOES satellite PAR data.

States outside of Texas: Biogenic emissions were calculated using GloBEIS2.2 with BELD-3 LULC data, interpolated observed temperature data and GOES satellite PAR data.

Mexico: Biogenic emissions were calculated using GloBEIS2.2 with TCEQ LULC data, interpolated observed temperature data and GOES satellite PAR data.

EMISSION SUMMARIES FOR 2010

The emission inventories for 2010 are summarized in Tables 2-2 through 2-9. These tables are:

- Tables 2-2 to 2-4 present episode day emission summaries for NO_x, VOC and CO by major source type for the DFW area counties. The major source categories are defined as area, on-road mobile, off-road mobile, stationary points and biogenic.
- Table 2-5 presents total gridded Texas emissions for each episode day.
- Table 2-6 summarizes the gridded emissions by major source type for states other than Texas.
- Table 2-7 presents the gridded biogenic emissions for states other than Texas.
- Table 2-8 shows the 2010 NOx and VOC emissions for the entire modeling domain broken out by several geographic areas.

Corresponding emissions summary tables for the latest 1999 base case (run 17b) are presented by Emery et al., (2004).

Figure 2-1 shows the geographic areas used in Table 2-8 which are the same as used in previous ozone source apportionment modeling (Mansell et al., 2003). Tables 2-8 through 2-10 show the emission inventories for the entire modeling domain in a concise format for just the August 17th day (Tuesday). The source categories in Tables 2-8 through 2-10 are biogenic, on-road mobile, stationary point sources (elevated plus low-level) and other anthropogenic sources. The other anthropogenic category combines area and off-road mobile sources. Table 2-11 provides the definition of the source regions corresponding to the numbered regions in Figure 2-1.

Table 2-8 presents the 1999 emissions totals and is prepared directly from model ready emissions files. This introduces some uncertainty into the emissions totals because: (1) County boundaries are approximated to the nearest grid-cell boundary, and; (2) The emissions processing provides CAMx with moles of emissions rather than tons of emissions. Therefore, in the case of minor differences between Tables 2-2 through 2-7 and Table 2-8, the former should be considered more accurate.

Table 2-9 shows the same information as Table 2-8 but for the 2010 future year rather than 1999 base year emission inventory. Comparing Tables 2-8 and 2-9 shows the trends in emissions from the base to future year resulting from the combined effects of activity growth and emission control strategies. Table 2-10 shows the ratio of the 2010 to 1999 emissions shown in Tables 2-8 and 2-9. In a few cases the ratios are large numbers because the 1999 emissions were very low, so care is needed in interpreting the ratios shown in Table 2-10. The following points are noted from the emissions trend analysis shown in Table 2-10:

- There are significant reductions in on-road mobile source NOx and VOC emissions in all regions from 1999 to 2010 resulting from cleaner vehicles and fuels.
- The on-road mobile source NOx emission reductions are influenced by new standards for heavy-duty diesel vehicles and therefore the overall on-road mobile source NOx reduction tends to be larger in areas with a high contribution from truck traffic.
- There are significant reductions in point source NOx emissions in most regions from 1999 to 2010, although the DFW perimeter counties show increases in point source NOx emissions.
- The 2010 point source NOx in the 4 core counties is substantially reduced, but increases in the surrounding 12 counties.
- Point source NOx emissions are substantially reduced in 2010 for the “Other States” region (region 25 in Figure 2-1) due to EPA’s NOx SIP call.
- Reductions in “other anthropogenic” NOx emissions tend to be less than for on-road mobile or point sources. Other anthropogenic combines off-road mobile and area sources.

The spatial distribution of the emissions is shown for each source category in Figures 2-2 through 2-7. The 4-km grid model ready emissions for Tuesday August 17th are shown in Figures 2-2 through 2-4 for NOx, VOC and CO, respectively. Figures 2-5 through 2-7 show the corresponding information for the 12-km CAMx grid.

The dates shown in the PAVE legends in Figures 2-2 through 2-7 are sometimes different from August 17th, 1999. This does not indicate any problems with the emission inventory: rather, future year area, off-road and low-level point emissions were prepared for representative weekdays from a Houston modeling episode (Wednesday August 30, 2000 or Thursday August 31, 2000) and used for DFW future case weekdays.

Table 2-2. 2010 NOx emissions by source category for the DFW area counties.

Date	Source Category	Collin 48085	Dallas 48113	Denton 48121	Ellis 48139	Hender-son 48213	Hood 48221	Hunt 48231	Johnson 48251	Kaufman 48257	Parker 48367	Rockwall 48397	Tarrant 48439
Friday, August 13	Area	2.17	19.35	10.88	0.31	3.91	0.28	0.27	0.29	0.19	1.25	0.10	11.42
	On-road	13.61	63.05	13.39	8.32	2.41	1.15	4.73	4.83	6.19	5.46	2.69	39.49
	Off-road	13.89	49.93	7.44	8.75	3.47	0.56	2.36	6.44	3.23	3.63	0.95	40.62
	Points	3.32	16.75	2.77	4.30	6.50	18.55	0.25	4.36	0.80	2.19	0.00	11.89
	Subtotal	33.00	149.09	34.48	21.69	16.28	20.55	7.61	15.92	10.41	12.54	3.74	103.42
	Biogenic	12.16	4.48	8.59	15.61	0.69	0.22	7.45	5.25	5.45	0.71	1.81	3.09
	Total	45.16	153.57	43.07	37.29	16.97	20.77	15.06	21.17	15.87	13.24	5.54	106.51
Saturday, August 14	Area	1.65	14.07	10.50	0.25	3.86	0.26	0.22	0.22	0.15	1.20	0.08	8.68
	On-road	9.19	41.23	8.99	5.13	1.89	0.89	3.36	3.33	4.06	3.60	1.48	27.04
	Off-road	9.78	37.87	5.67	6.44	3.64	0.46	2.14	6.07	2.95	3.43	0.66	33.11
	Points	2.31	16.30	2.54	4.29	7.08	17.05	0.25	4.26	0.80	2.30	0.00	11.36
	Subtotal	22.93	109.46	27.71	16.10	16.47	18.67	5.97	13.88	7.95	10.53	2.22	80.18
	Biogenic	11.78	4.50	8.46	15.74	0.67	0.23	7.09	5.38	5.37	0.72	1.77	3.16
	Total	34.71	113.96	36.17	31.85	17.14	18.89	13.06	19.27	13.32	11.25	3.99	83.34
Sunday, August 15	Area	1.13	8.78	10.12	0.19	3.82	0.24	0.18	0.15	0.10	1.15	0.06	5.93
	On-road	7.04	31.55	6.71	4.86	1.98	0.89	3.38	3.26	4.03	3.34	1.10	19.59
	Off-road	7.70	30.49	4.61	5.34	3.54	0.38	1.86	5.82	2.74	3.30	0.49	28.50
	Points	2.80	15.85	2.52	4.29	7.10	18.94	0.10	4.33	0.80	2.34	0.00	11.96
	Subtotal	18.67	86.68	23.96	14.68	16.44	20.46	5.51	13.56	7.68	10.13	1.65	65.98
	Biogenic	11.13	4.20	8.14	14.81	0.62	0.22	6.61	5.14	4.98	0.71	1.65	3.02
	Total	29.80	90.88	32.10	29.49	17.05	20.68	12.12	18.70	12.65	10.83	3.29	68.99
Monday, August 16	Area	2.17	19.35	10.88	0.31	3.91	0.28	0.27	0.29	0.19	1.25	0.10	11.42
	On-road	13.83	63.62	13.63	6.89	2.04	0.95	4.03	4.05	5.28	4.67	2.75	39.87
	Off-road	13.89	49.93	7.44	8.75	3.47	0.56	2.36	6.44	3.23	3.63	0.95	40.62
	Points	3.32	16.75	2.77	4.30	6.50	18.55	0.25	4.36	0.80	2.19	0.00	11.89
	Subtotal	33.22	149.65	34.72	20.25	15.91	20.35	6.92	15.14	9.50	11.74	3.80	103.81
	Biogenic	10.85	4.08	7.96	14.30	0.59	0.22	6.42	4.97	4.80	0.69	1.60	2.93
	Total	44.08	153.73	42.68	34.55	16.50	20.56	13.33	20.11	14.31	12.43	5.40	106.74
Tuesday, August 17	Area	2.17	19.35	10.88	0.31	3.91	0.28	0.27	0.29	0.19	1.25	0.10	11.42
	On-road	13.90	63.14	13.85	6.88	2.02	0.94	4.01	3.97	5.20	4.72	2.71	40.06
	Off-road	13.89	49.93	7.44	8.75	3.47	0.56	2.36	6.44	3.23	3.63	0.95	40.62
	Points	3.32	16.75	2.77	4.30	6.50	18.55	0.25	4.36	0.80	2.19	0.00	11.89
	Subtotal	33.29	149.18	34.93	20.24	15.89	20.33	6.89	15.06	9.42	11.80	3.75	104.00
	Biogenic	11.18	4.18	7.99	14.51	0.63	0.21	6.78	4.94	5.02	0.67	1.67	2.92
	Total	44.47	153.36	42.92	34.75	16.52	20.55	13.67	20.00	14.45	12.46	5.42	106.92

Date	Source Category	Collin 48085	Dallas 48113	Denton 48121	Ellis 48139	Hender-son 48213	Hood 48221	Hunt 48231	Johnson 48251	Kaufman 48257	Parker 48367	Rockwall 48397	Tarrant 48439
Wednesday, August 18	Area	2.17	19.35	10.88	0.31	3.91	0.28	0.27	0.29	0.19	1.25	0.10	11.42
	On-road	13.27	60.93	13.15	6.78	1.92	0.88	3.82	3.75	4.96	4.50	2.58	37.93
	Off-road	13.89	49.93	7.44	8.75	3.47	0.56	2.36	6.44	3.23	3.63	0.95	40.62
	Points	3.32	16.75	2.77	4.30	6.50	18.55	0.25	4.36	0.80	2.19	0.00	11.89
	Subtotal	32.66	146.97	34.24	20.14	15.79	20.28	6.71	14.85	9.18	11.58	3.63	101.87
	Biogenic	12.11	4.57	8.63	15.84	0.69	0.22	7.35	5.34	5.50	0.71	1.82	3.17
	Total	44.78	151.54	42.87	35.98	16.48	20.50	14.06	20.19	14.68	12.29	5.45	105.04
Thursday, August 19	Area	2.17	19.35	10.88	0.31	3.91	0.28	0.27	0.29	0.19	1.25	0.10	11.42
	On-road	13.68	61.59	13.09	6.76	1.93	0.91	3.91	3.81	5.01	4.47	2.63	37.87
	Off-road	13.89	49.93	7.44	8.75	3.47	0.56	2.36	6.44	3.23	3.63	0.95	40.62
	Points	3.32	16.75	2.77	4.30	6.50	18.55	0.25	4.36	0.80	2.19	0.00	11.89
	Subtotal	33.07	147.63	34.18	20.13	15.81	20.30	6.79	14.90	9.23	11.54	3.68	101.80
	Biogenic	12.47	4.73	8.76	16.44	0.73	0.22	7.61	5.41	5.74	0.70	1.89	3.18
	Total	45.54	152.37	42.94	36.56	16.53	20.53	14.40	20.31	14.97	12.24	5.57	104.98
Friday, August 20	Area	2.17	19.35	10.88	0.31	3.91	0.28	0.27	0.29	0.19	1.25	0.10	11.42
	On-road	15.80	69.85	15.40	8.93	2.73	1.32	5.46	5.54	6.98	6.41	3.09	45.49
	Off-road	13.89	49.93	7.44	8.75	3.47	0.56	2.36	6.44	3.23	3.63	0.95	40.62
	Points	3.32	16.75	2.77	4.30	6.50	18.55	0.25	4.36	0.80	2.19	0.00	11.89
	Subtotal	35.19	155.89	36.49	22.30	16.60	20.72	8.34	16.63	11.21	13.48	4.14	109.42
	Biogenic	10.80	4.17	7.59	14.84	0.68	0.20	6.62	4.88	5.12	0.62	1.66	2.81
	Total	45.99	160.06	44.08	37.14	17.28	20.92	14.96	21.51	16.32	14.11	5.80	112.23
Saturday, August 21	Area	1.65	14.07	10.50	0.25	3.86	0.26	0.22	0.22	0.15	1.20	0.08	8.68
	On-road	9.52	42.83	9.12	5.25	1.97	0.95	3.49	3.53	4.22	3.72	1.54	26.89
	Off-road	9.78	37.87	5.67	6.44	3.64	0.46	2.14	6.07	2.95	3.43	0.66	33.11
	Points	2.31	16.30	2.54	4.29	7.08	17.05	0.25	4.26	0.80	2.30	0.00	11.36
	Subtotal	23.26	111.06	27.84	16.23	16.56	18.72	6.10	14.08	8.12	10.65	2.28	80.04
	Biogenic	10.71	4.06	7.67	14.23	0.63	0.20	6.46	4.77	4.90	0.63	1.61	2.81
	Total	33.97	115.12	35.51	30.46	17.18	18.92	12.57	18.85	13.02	11.29	3.88	82.85
Sunday, August 22	Area	1.13	8.78	10.12	0.19	3.82	0.24	0.18	0.15	0.10	1.15	0.06	5.93
	On-road	6.73	31.44	6.60	4.80	1.88	0.90	3.20	3.26	3.82	3.33	1.04	19.41
	Off-road	7.70	30.49	4.61	5.34	3.54	0.38	1.86	5.82	2.74	3.30	0.49	28.50
	Points	2.80	15.85	2.52	4.29	7.10	18.94	0.10	4.33	0.80	2.34	0.00	11.96
	Subtotal	18.35	86.57	23.85	14.62	16.34	20.46	5.33	13.56	7.47	10.11	1.59	65.79
	Biogenic	11.87	4.44	8.42	15.32	0.66	0.22	7.17	5.15	5.34	0.69	1.77	3.04
	Total	30.23	91.01	32.27	29.93	17.00	20.68	12.50	18.70	12.81	10.80	3.36	68.83

Table 2-3. 2010 VOC emissions by source category for the DFW area counties.

Date	Source Category	Collin 48085	Dallas 48113	Denton 48121	Ellis 48139	Hender-son 48213	Hood 48221	Hunt 48231	Johnson 48251	Kaufman 48257	Parker 48367	Rockwall 48397	Tarrant 48439
Friday, August 13	Area	14.93	84.90	19.77	12.37	10.81	4.38	13.32	13.01	13.80	11.76	3.34	65.59
	On-road	9.44	41.99	8.73	2.93	2.16	0.95	2.85	2.75	3.06	2.37	0.98	25.56
	Off-road	4.40	24.53	4.17	1.94	1.86	0.32	1.89	0.77	0.76	0.89	0.50	15.48
	Points	1.30	12.82	1.88	3.43	0.66	0.40	0.06	0.39	0.38	0.92	0.00	9.08
	Subtotal	30.06	164.24	34.55	20.68	15.48	6.05	18.12	16.92	18.00	15.93	4.81	115.71
	Biogenic	24.94	47.78	52.42	87.80	270.77	29.24	66.90	89.97	102.23	108.72	3.28	48.72
	Total	55.01	212.03	86.97	108.47	286.25	35.28	85.02	106.90	120.23	124.65	8.09	164.43
Saturday, August 14	Area	10.41	47.97	12.63	8.77	8.63	3.61	7.99	8.99	7.16	9.62	2.42	32.83
	On-road	6.63	29.55	6.21	2.53	1.89	0.84	2.50	2.39	2.65	2.08	0.69	18.13
	Off-road	6.10	30.31	8.51	2.91	5.66	0.97	4.56	1.01	1.62	1.54	1.27	20.55
	Points	0.65	9.69	1.07	3.33	0.70	0.40	0.05	0.39	0.38	0.92	0.00	6.45
	Subtotal	23.79	117.52	28.41	17.54	16.88	5.82	15.11	12.78	11.81	14.17	4.37	77.97
	Biogenic	27.84	55.51	63.41	94.23	274.45	36.68	74.66	113.29	109.44	134.33	3.69	64.04
	Total	51.63	173.03	91.83	111.77	291.33	42.50	89.76	126.07	121.25	148.50	8.07	142.02
Sunday, August 15	Area	7.24	32.71	9.88	5.88	6.88	2.79	4.88	6.21	4.71	7.48	1.66	22.65
	On-road	5.29	23.48	4.92	2.58	1.91	0.86	2.54	2.44	2.68	2.14	0.55	14.45
	Off-road	5.50	27.80	8.14	2.71	5.59	0.93	4.46	0.90	1.54	1.47	1.23	18.87
	Points	0.65	9.72	1.07	3.33	0.70	0.40	0.05	0.39	0.38	0.92	0.00	6.51
	Subtotal	18.67	93.71	24.02	14.50	15.08	4.99	11.92	9.93	9.32	12.00	3.43	62.47
	Biogenic	25.42	48.95	60.56	82.51	230.43	35.33	66.00	104.71	93.77	131.95	3.24	59.68
	Total	44.10	142.67	84.57	97.01	245.51	40.32	77.92	114.64	103.09	143.96	6.67	122.15
Monday, August 16	Area	14.93	84.90	19.77	12.37	10.81	4.38	13.32	13.01	13.80	11.76	3.34	65.59
	On-road	8.51	37.56	7.93	2.19	1.62	0.72	2.14	2.05	2.30	1.79	0.86	23.15
	Off-road	4.40	24.53	4.17	1.94	1.86	0.32	1.89	0.77	0.76	0.89	0.50	15.48
	Points	1.30	12.82	1.88	3.43	0.66	0.40	0.06	0.39	0.38	0.92	0.00	9.08
	Subtotal	29.14	159.81	33.75	19.94	14.94	5.82	17.40	16.23	17.24	15.35	4.69	113.30
	Biogenic	25.72	49.59	61.60	82.66	231.67	34.72	67.06	104.12	94.89	131.12	3.26	60.22
	Total	54.85	209.40	95.35	102.60	246.61	40.54	84.46	120.34	112.13	146.48	7.96	173.53
Tuesday, August 17	Area	14.93	84.90	19.77	12.37	10.81	4.38	13.32	13.01	13.80	11.76	3.34	65.59
	On-road	8.79	38.57	8.19	2.21	1.64	0.73	2.17	2.08	2.34	1.83	0.88	23.61
	Off-road	4.40	24.53	4.17	1.94	1.86	0.32	1.89	0.77	0.76	0.89	0.50	15.48
	Points	1.30	12.82	1.88	3.43	0.66	0.40	0.06	0.39	0.38	0.92	0.00	9.08
	Subtotal	29.41	160.82	34.01	19.96	14.97	5.83	17.44	16.25	17.27	15.39	4.72	113.76
	Biogenic	27.37	51.14	62.39	84.35	248.62	32.99	74.21	100.61	101.34	126.55	3.51	59.67
	Total	56.79	211.96	96.40	104.31	263.58	38.82	91.64	116.86	118.61	141.94	8.23	173.44

Date	Source Category	Collin 48085	Dallas 48113	Denton 48121	Ellis 48139	Hender-son 48213	Hood 48221	Hunt 48231	Johnson 48251	Kaufman 48257	Parker 48367	Rockwall 48397	Tarrant 48439
Wednesday, August 18	Area	14.93	84.90	19.77	12.37	10.81	4.38	13.32	13.01	13.80	11.76	3.34	65.59
	On-road	8.83	38.86	8.20	2.23	1.65	0.73	2.17	2.09	2.34	1.83	0.89	23.69
	Off-road	4.40	24.53	4.17	1.94	1.86	0.32	1.89	0.77	0.76	0.89	0.50	15.48
	Points	1.30	12.82	1.88	3.43	0.66	0.40	0.06	0.39	0.38	0.92	0.00	9.08
	Subtotal	29.46	161.11	34.02	19.97	14.97	5.83	17.44	16.27	17.28	15.40	4.72	113.84
	Biogenic	29.50	55.34	66.21	91.30	269.69	34.85	79.64	107.25	109.25	132.32	3.81	63.65
	Total	58.96	216.45	100.23	111.27	284.66	40.68	97.08	123.52	126.53	147.72	8.53	177.49
Thursday, August 19	Area	14.93	84.90	19.77	12.37	10.81	4.38	13.32	13.01	13.80	11.76	3.34	65.59
	On-road	8.95	38.99	8.25	2.27	1.66	0.73	2.19	2.14	2.36	1.84	0.89	23.80
	Off-road	4.40	24.53	4.17	1.94	1.86	0.32	1.89	0.77	0.76	0.89	0.50	15.48
	Points	1.30	12.82	1.88	3.43	0.66	0.40	0.06	0.39	0.38	0.92	0.00	9.08
	Subtotal	29.58	161.24	34.08	20.02	14.98	5.83	17.46	16.31	17.30	15.40	4.73	113.95
	Biogenic	30.90	58.87	68.30	98.82	297.09	36.42	83.84	114.86	117.00	133.77	4.00	66.11
	Total	60.48	220.11	102.38	118.84	312.08	42.25	101.30	131.17	134.30	149.17	8.73	180.06
Friday, August 20	Area	14.93	84.90	19.77	12.37	10.81	4.38	13.32	13.01	13.80	11.76	3.34	65.59
	On-road	9.48	41.71	8.82	2.91	2.13	0.95	2.81	2.72	3.02	2.38	0.98	25.62
	Off-road	4.40	24.53	4.17	1.94	1.86	0.32	1.89	0.77	0.76	0.89	0.50	15.48
	Points	1.30	12.82	1.88	3.43	0.66	0.40	0.06	0.39	0.38	0.92	0.00	9.08
	Subtotal	30.10	163.96	34.64	20.66	15.45	6.05	18.08	16.90	17.96	15.94	4.81	115.77
	Biogenic	25.12	49.93	56.28	87.45	268.22	31.89	69.06	100.81	101.82	114.81	3.38	56.14
	Total	55.22	213.88	90.92	108.10	283.67	37.95	87.14	117.71	119.78	130.76	8.19	171.91
Saturday, August 21	Area	10.41	47.97	12.63	8.77	8.63	3.61	7.99	8.99	7.16	9.62	2.42	32.83
	On-road	6.55	28.94	6.11	2.46	1.83	0.82	2.43	2.32	2.58	2.03	0.67	17.81
	Off-road	6.10	30.31	8.51	2.91	5.66	0.97	4.56	1.01	1.62	1.54	1.27	20.55
	Points	0.65	9.69	1.07	3.33	0.70	0.40	0.05	0.39	0.38	0.92	0.00	6.45
	Subtotal	23.71	116.91	28.31	17.46	16.82	5.79	15.03	12.70	11.74	14.12	4.36	77.65
	Biogenic	24.38	47.95	56.24	82.07	241.99	31.79	65.47	97.77	95.11	116.78	3.21	55.63
	Total	48.09	164.86	84.56	99.53	258.81	37.59	80.50	110.47	106.85	130.90	7.57	133.28
Sunday, August 22	Area	7.24	32.71	9.88	5.88	6.88	2.79	4.88	6.21	4.71	7.48	1.66	22.65
	On-road	5.33	23.62	4.97	2.58	1.93	0.87	2.56	2.44	2.70	2.14	0.54	14.48
	Off-road	5.50	27.80	8.14	2.71	5.59	0.93	4.46	0.90	1.54	1.47	1.23	18.87
	Points	0.65	9.72	1.07	3.33	0.70	0.40	0.05	0.39	0.38	0.92	0.00	6.51
	Subtotal	18.72	93.85	24.06	14.50	15.10	4.99	11.95	9.93	9.34	12.01	3.42	62.50
	Biogenic	26.10	49.01	58.86	82.15	240.53	33.03	69.19	98.26	96.24	124.47	3.37	56.80
	Total	44.82	142.86	82.92	96.65	255.63	38.02	81.14	108.19	105.58	136.48	6.80	119.30

Table 2-4. 2010 CO emissions by source category for the DFW area counties.

Date	Source Category	Collin 48085	Dallas 48113	Denton 48121	Ellis 48139	Henderson 48213	Hood 48221	Hunt 48231	Johnson 48251	Kaufman 48257	Parker 48367	Rockwall 48397	Tarrant 48439
Friday, August 13	Area	7.76	32.45	15.49	3.10	5.28	0.52	2.10	1.66	0.99	1.93	0.48	19.40
	On-road	151.62	652.83	142.76	45.03	26.91	12.81	38.62	36.38	42.40	32.67	16.34	406.99
	Off-road	111.07	623.60	70.58	27.27	17.77	7.12	18.52	18.04	18.47	16.42	10.25	314.92
	Points	2.19	15.37	1.65	4.56	4.72	5.30	0.08	1.33	0.11	1.46	0.00	13.72
	Subtotal	272.64	1324.25	230.47	79.96	54.69	25.76	59.31	57.40	61.96	52.48	27.07	755.04
	Biogenic	2.19	4.01	3.18	6.91	17.32	5.93	5.00	6.84	5.95	10.88	0.30	3.95
	Total	274.83	1328.26	233.65	86.87	72.01	31.68	64.31	64.24	67.92	63.35	27.37	758.99
Saturday, August 14	Area	6.15	18.34	14.80	2.13	4.87	0.39	1.71	1.15	0.66	1.65	0.35	11.67
	On-road	111.32	491.43	106.66	40.86	23.70	11.24	34.63	32.38	37.52	28.97	12.05	304.07
	Off-road	127.73	703.34	100.58	35.79	36.97	12.41	31.19	24.41	27.24	24.48	14.26	384.22
	Points	2.10	15.23	1.63	4.54	4.90	5.30	0.07	1.32	0.11	1.46	0.00	12.71
	Subtotal	247.30	1228.34	223.67	83.33	70.44	29.34	67.61	59.26	65.53	56.56	26.66	712.66
	Biogenic	2.12	4.09	3.19	6.96	16.51	6.18	4.70	7.16	5.84	11.35	0.30	4.18
	Total	249.42	1232.43	226.86	90.29	86.94	35.53	72.30	66.42	71.37	67.91	26.96	716.84
Sunday, August 15	Area	4.58	4.48	14.12	1.18	4.46	0.26	1.34	0.66	0.34	1.38	0.21	4.07
	On-road	89.53	392.65	86.33	42.66	24.62	11.87	36.08	33.73	38.78	30.81	9.70	248.30
	Off-road	107.16	615.69	86.21	30.52	33.88	10.96	27.57	19.86	24.39	21.37	12.63	321.96
	Points	2.10	15.69	1.63	4.54	4.90	5.30	0.07	1.32	0.11	1.46	0.00	13.62
	Subtotal	203.37	1028.51	188.29	78.91	67.87	28.38	65.05	55.56	63.62	55.03	22.54	587.96
	Biogenic	1.93	3.65	2.98	6.26	14.47	5.95	4.19	6.69	5.16	11.05	0.26	3.86
	Total	205.30	1032.16	191.27	85.17	82.34	34.33	69.24	62.25	68.78	66.07	22.80	591.82
Monday, August 16	Area	7.76	32.45	15.49	3.10	5.28	0.52	2.10	1.66	0.99	1.93	0.48	19.40
	On-road	131.61	560.80	123.52	32.55	19.74	9.34	28.14	26.19	30.70	23.55	14.08	354.10
	Off-road	111.07	623.60	70.58	27.27	17.77	7.12	18.52	18.04	18.47	16.42	10.25	314.92
	Points	2.19	15.37	1.65	4.56	4.72	5.30	0.08	1.33	0.11	1.46	0.00	13.72
	Subtotal	252.63	1232.21	211.24	67.48	47.51	22.28	48.84	47.21	50.27	43.36	24.81	702.15
	Biogenic	1.87	3.53	2.91	5.98	13.63	5.73	4.04	6.42	4.94	10.69	0.26	3.72
	Total	254.50	1235.75	214.14	73.46	61.14	28.01	52.88	53.63	55.20	54.05	25.07	705.87
Tuesday, August 17	Area	7.76	32.45	15.49	3.10	5.28	0.52	2.10	1.66	0.99	1.93	0.48	19.40
	On-road	136.28	578.06	128.03	33.23	20.26	9.55	28.93	26.84	31.69	23.98	14.53	362.80
	Off-road	111.07	623.60	70.58	27.27	17.77	7.12	18.52	18.04	18.47	16.42	10.25	314.92
	Points	2.19	15.37	1.65	4.56	4.72	5.30	0.08	1.33	0.11	1.46	0.00	13.72
	Subtotal	257.30	1249.48	215.75	68.17	48.04	22.49	49.63	47.86	51.26	43.79	25.26	710.84
	Biogenic	1.97	3.68	2.92	6.22	15.17	5.44	4.44	6.28	5.33	10.17	0.27	3.70
	Total	259.27	1253.16	218.66	74.39	63.21	27.93	54.06	54.14	56.58	53.96	25.53	714.54

Date	Source Category	Collin 48085	Dallas 48113	Denton 48121	Ellis 48139	Hender-son 48213	Hood 48221	Hunt 48231	Johnson 48251	Kaufman 48257	Parker 48367	Rockwall 48397	Tarrant 48439
Wednesday, August 18	Area	7.76	32.45	15.49	3.10	5.28	0.52	2.10	1.66	0.99	1.93	0.48	19.40
	On-road	136.18	592.85	128.11	33.72	20.12	9.70	28.78	27.54	31.57	24.48	14.49	369.52
	Off-road	111.07	623.60	70.58	27.27	17.77	7.12	18.52	18.04	18.47	16.42	10.25	314.92
	Points	2.19	15.37	1.65	4.56	4.72	5.30	0.08	1.33	0.11	1.46	0.00	13.72
	Subtotal	257.20	1264.27	215.83	68.65	47.90	22.65	49.47	48.56	51.14	44.29	25.22	717.56
	Biogenic	2.22	4.19	3.27	7.08	17.31	5.92	5.00	6.98	6.07	11.03	0.31	4.17
	Total	259.42	1268.46	219.10	75.74	65.21	28.56	54.47	55.54	57.21	55.32	25.53	721.73
Thursday, August 19	Area	7.76	32.45	15.49	3.10	5.28	0.52	2.10	1.66	0.99	1.93	0.48	19.40
	On-road	137.83	593.22	129.66	34.08	20.13	9.66	28.70	27.76	31.55	24.49	14.55	369.08
	Off-road	111.07	623.60	70.58	27.27	17.77	7.12	18.52	18.04	18.47	16.42	10.25	314.92
	Points	2.19	15.37	1.65	4.56	4.72	5.30	0.08	1.33	0.11	1.46	0.00	13.72
	Subtotal	258.85	1264.64	217.38	69.02	47.90	22.61	49.40	48.78	51.12	44.29	25.28	717.12
	Biogenic	2.31	4.42	3.33	7.60	18.98	5.97	5.27	7.16	6.53	10.84	0.33	4.19
	Total	261.16	1269.06	220.70	76.62	66.89	28.58	54.67	55.94	57.65	55.13	25.61	721.31
Friday, August 20	Area	7.76	32.45	15.49	3.10	5.28	0.52	2.10	1.66	0.99	1.93	0.48	19.40
	On-road	144.85	625.68	136.75	44.14	26.10	12.45	37.24	35.14	40.60	31.26	15.77	388.26
	Off-road	111.07	623.60	70.58	27.27	17.77	7.12	18.52	18.04	18.47	16.42	10.25	314.92
	Points	2.19	15.37	1.65	4.56	4.72	5.30	0.08	1.33	0.11	1.46	0.00	13.72
	Subtotal	265.87	1297.10	224.47	79.08	53.87	25.40	57.93	56.16	60.17	51.07	26.50	736.31
	Biogenic	1.85	3.63	2.68	6.51	16.97	5.20	4.27	6.20	5.51	9.21	0.27	3.49
	Total	267.73	1300.74	227.15	85.59	70.84	30.60	62.20	62.37	65.68	60.28	26.77	739.79
Saturday, August 21	Area	6.15	18.34	14.80	2.13	4.87	0.39	1.71	1.15	0.66	1.65	0.35	11.67
	On-road	109.80	476.34	104.99	39.73	23.28	11.00	33.99	31.21	36.62	28.23	11.84	299.02
	Off-road	127.73	703.34	100.58	35.79	36.97	12.41	31.19	24.41	27.24	24.48	14.26	384.22
	Points	2.10	15.23	1.63	4.54	4.90	5.30	0.07	1.32	0.11	1.46	0.00	12.71
	Subtotal	245.78	1213.25	221.99	82.20	70.02	29.10	66.97	58.09	64.63	55.83	26.45	707.61
	Biogenic	1.83	3.51	2.74	6.07	15.00	5.19	4.10	6.02	5.12	9.48	0.26	3.49
	Total	247.61	1216.75	224.72	88.27	85.01	34.29	71.07	64.11	69.76	65.31	26.71	711.09
Sunday, August 22	Area	4.58	4.48	14.12	1.18	4.46	0.26	1.34	0.66	0.34	1.38	0.21	4.07
	On-road	91.75	396.79	87.64	43.07	25.00	11.90	36.71	33.98	39.64	30.93	9.76	249.17
	Off-road	107.16	615.69	86.21	30.52	33.88	10.96	27.57	19.86	24.39	21.37	12.63	321.96
	Points	2.10	15.69	1.63	4.54	4.90	5.30	0.07	1.32	0.11	1.46	0.00	13.62
	Subtotal	205.59	1032.65	189.59	79.32	68.25	28.42	65.68	55.81	64.48	55.15	22.60	588.82
	Biogenic	2.13	3.98	3.11	6.71	16.21	5.64	4.75	6.58	5.75	10.61	0.30	3.89
	Total	207.72	1036.63	192.70	86.03	84.45	34.06	70.44	62.39	70.24	65.76	22.90	592.71

Table 2-5. 2010 total gridded Texas emissions for each episode day by source.

Date	Area	On-Road Mobile	Off-Road Mobile	Elevated Points	Low Level Points	Anthro-pogenic	Biogenic
Tons NOx							
Friday, August 13	512.02	770.51	730.44	1328.09	15.27	3356.32	1099.63
Saturday, August 14	489.06	532.61	652.02	1272.15	14.61	2960.44	1081.88
Sunday, August 15	466.11	407.41	592.66	1262.85	14.61	2743.65	1104.89
Monday, August 16	512.02	786.72	730.44	1328.09	15.27	3372.53	1082.30
Tuesday, August 17	512.02	786.49	730.44	1328.09	15.27	3372.30	1040.07
Wednesday, August 18	512.02	779.58	730.44	1328.09	15.27	3365.40	1078.05
Thursday, August 19	512.02	780.76	730.44	1328.09	15.27	3366.57	1067.56
Friday, August 20	512.02	792.18	730.44	1328.09	15.27	3377.99	1051.84
Saturday, August 21	489.06	535.47	652.02	1272.15	14.61	2963.30	1052.74
Sunday, August 22	466.11	406.07	592.66	1262.85	14.61	2742.31	1010.18
Tons VOC							
Friday, August 13	2008.88	462.36	320.16	201.27	53.99	3046.67	22086.99
Saturday, August 14	1557.78	347.52	689.28	197.85	27.76	2820.21	20527.24
Sunday, August 15	1218.63	297.65	668.68	197.71	27.76	2410.44	20445.18
Monday, August 16	2008.88	391.25	320.16	201.27	53.99	2975.56	19998.45
Tuesday, August 17	2008.88	393.47	320.16	201.27	53.99	2977.78	19290.33
Wednesday, August 18	2008.88	393.95	320.16	201.27	53.99	2978.26	20752.08
Thursday, August 19	2008.88	394.52	320.16	201.27	53.99	2978.82	21744.80
Friday, August 20	2008.88	462.13	320.16	201.27	53.99	3046.43	20787.51
Saturday, August 21	1557.78	345.98	689.28	197.85	27.76	2818.66	19564.64
Sunday, August 22	1218.63	297.98	668.68	197.71	27.76	2410.76	18023.32
Tons CO							
Friday, August 13	979.47	6650.39	4646.26	1079.44	11.46	13367.02	2269.61
Saturday, August 14	831.85	5347.28	6885.44	1068.42	11.18	14144.17	2158.57
Sunday, August 15	687.21	4594.04	6110.60	1067.76	11.18	12470.78	2127.63
Monday, August 16	979.47	5516.23	4646.26	1079.44	11.46	12232.86	2078.00
Tuesday, August 17	979.47	5556.11	4646.26	1079.44	11.46	12272.73	2005.15
Wednesday, August 18	979.47	5578.99	4646.26	1079.44	11.46	12295.61	2135.58
Thursday, August 19	979.47	5582.63	4646.26	1079.44	11.46	12299.26	2212.06
Friday, August 20	979.47	6583.29	4646.26	1079.44	11.46	13299.92	2127.41
Saturday, August 21	831.85	5318.49	6885.44	1068.42	11.18	14115.38	2044.69
Sunday, August 22	687.21	4605.33	6110.60	1067.76	11.18	12482.07	1962.74

Table 2-6. 2010 total gridded emissions for state other than Texas.

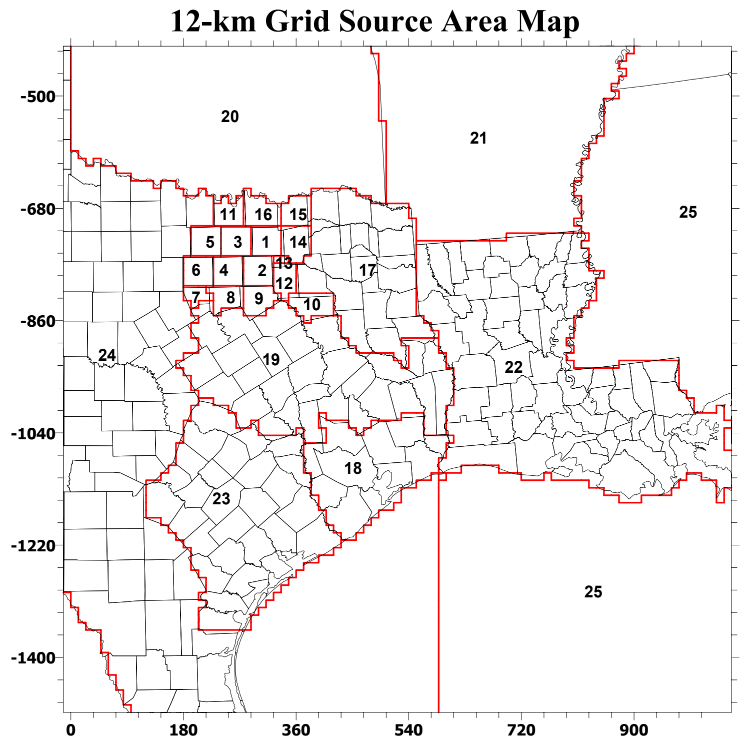
State	Area			On-Road Mobile			Off-Road Mobile			Low Level Points			Total Anthropogenic		
	Wkd	Sat	Sun	Wkd	Sat	Sun	Wkd	Sat	Sun	Wkd	Sat	Sun	Wkd	Sat	Sun
Tons NOx															
Alabama	167.99	154.82	148.23	236.62	160.90	123.04	177.78	188.10	175.96	692.66	684.36	680.94	1275.05	1188.18	1128.18
Arkansas	130.51	120.18	115.02	114.59	77.92	59.59	128.09	131.72	122.73	316.98	301.21	313.38	690.16	631.04	610.72
Florida	5.72	5.27	5.04	55.22	37.55	28.72	54.16	66.48	62.87	132.56	124.84	120.95	247.66	234.14	217.57
Georgia	59.64	56.02	54.22	312.50	212.50	162.50	158.16	148.70	130.55	449.62	386.87	410.24	979.93	804.09	757.50
Illinois	13.09	12.39	12.04	117.29	79.76	60.99	188.29	188.46	182.50	509.99	499.48	494.53	828.66	780.08	750.06
Indiana	33.17	30.74	29.53	150.03	102.02	78.02	120.13	116.15	107.55	611.57	593.98	569.03	914.90	842.90	784.12
Kansas	257.66	236.96	226.61	101.60	69.09	52.83	292.98	287.11	275.63	507.78	462.78	479.65	1160.02	1055.94	1034.73
Kentucky	267.53	246.52	236.01	210.48	143.13	109.45	230.88	234.53	223.72	584.51	542.37	535.40	1293.40	1166.54	1104.58
Louisiana	363.55	334.28	319.65	179.05	121.75	93.11	616.93	632.78	619.09	998.39	1018.60	979.05	2157.92	2107.41	2010.90
Mississippi	162.16	149.28	142.84	166.10	112.95	86.37	148.04	155.03	146.85	593.29	561.76	508.51	1069.59	979.02	884.58
Missouri	39.97	37.06	35.61	288.80	196.38	150.18	280.50	296.88	279.22	542.97	518.09	517.56	1152.24	1048.42	982.57
Nebraska	4.53	4.18	4.01	15.82	10.75	8.22	42.20	42.13	41.51	30.81	30.52	30.52	93.35	87.59	84.27
North Carolina	0.69	0.69	0.69	10.71	7.28	5.57	2.86	2.81	2.37	13.95	13.93	13.93	28.21	24.72	22.56
Ohio	24.17	22.39	21.50	71.09	48.34	36.97	49.07	44.22	38.01	376.91	328.03	326.44	521.25	442.99	422.92
Oklahoma	105.05	96.77	92.63	176.89	120.28	91.98	235.72	246.92	230.52	687.10	685.13	704.34	1204.75	1149.10	1119.47
South Carolina	0.11	0.11	0.10	3.19	2.17	1.66	0.28	0.31	0.27	0.02	0.02	0.02	3.61	2.61	2.05
Tennessee	70.84	66.67	64.59	283.53	192.80	147.44	420.99	424.93	408.04	600.23	619.19	612.05	1375.60	1303.59	1232.11
Virginia	1.05	0.99	0.96	4.08	2.77	2.12	2.71	2.38	2.01	0.23	0.20	0.20	8.07	6.35	5.30
West Virginia	2.99	2.79	2.70	11.14	7.58	5.79	42.27	42.15	41.20	121.49	120.94	120.94	177.89	173.46	170.63
Total	**1710.42**	**1578.13**	**1511.98**	**2508.75**	**1705.95**	**1304.55**	**3192.04**	**3251.76**	**3090.60**	**7771.06**	**7492.30**	**7417.68**	**15182.27**	**14028.14**	**13324.81**
Tons VOC															
Alabama	403.44	403.25	403.16	152.77	134.43	114.57	107.11	240.43	238.80	379.02	314.34	314.34	1042.33	1092.45	1070.88
Arkansas	364.76	364.64	364.58	62.82	55.28	47.12	73.23	159.58	158.34	125.31	105.29	105.29	626.12	684.79	675.33
Florida	121.71	121.71	121.70	35.01	30.81	26.26	62.73	141.03	140.55	18.99	17.18	17.18	238.45	310.73	305.69
Georgia	498.24	498.17	498.14	179.93	158.34	134.95	108.02	168.44	165.98	74.89	68.24	68.24	861.08	893.19	867.30
Illinois	182.00	181.99	181.98	64.24	56.53	48.18	50.85	85.07	84.20	220.82	154.50	154.24	517.92	478.09	468.59
Indiana	249.34	249.31	249.29	95.15	83.73	71.37	40.04	67.51	66.31	73.23	42.85	42.85	457.76	443.40	429.82
Kansas	373.57	373.29	373.15	66.42	58.45	49.82	64.30	96.82	95.18	90.04	54.01	53.92	594.34	582.57	572.06
Kentucky	392.85	392.55	392.39	121.85	107.23	91.39	82.14	173.04	171.51	271.35	203.07	203.03	868.19	875.88	858.32
Louisiana	330.91	330.51	330.31	102.66	90.34	76.99	129.20	299.20	297.36	251.51	253.16	253.31	814.27	973.21	957.97
Mississippi	388.00	387.86	387.78	83.51	73.49	62.63	75.11	169.50	168.41	167.63	152.49	152.43	714.25	783.34	771.26
Missouri	436.38	436.29	436.24	169.32	149.00	126.99	146.15	326.42	323.94	258.86	196.39	196.39	1010.72	1108.09	1083.55
Nebraska	44.32	44.32	44.32	10.00	8.80	7.50	6.31	8.88	8.78	4.32	4.11	4.11	64.96	66.11	64.71
North Carolina	18.13	18.13	18.13	5.11	4.49	3.83	5.25	10.49	10.43	9.21	2.86	2.86	37.70	35.97	35.25

State	Area			On-Road Mobile			Off-Road Mobile			Low Level Points			Total Anthropogenic		
	Wkd	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**
Ohio	136.24	136.22	136.20	48.63	42.79	36.47	29.48	37.80	36.95	54.58	36.55	35.66	268.93	253.37	245.28
Oklahoma	300.61	300.50	300.44	108.91	95.84	81.69	128.08	284.64	282.35	199.01	168.63	168.63	736.62	849.61	833.11
South Carolina	1.75	1.75	1.75	1.76	1.55	1.32	0.54	1.17	1.17	0.19	0.19	0.19	4.24	4.66	4.43
Tennessee	696.23	696.07	695.99	163.78	144.12	122.83	119.26	245.26	242.95	388.56	205.81	205.81	1367.83	1291.27	1267.59
Virginia	8.34	8.33	8.33	2.88	2.54	2.16	0.62	0.74	0.69	0.73	0.12	0.12	12.57	11.74	11.30
West Virginia	15.88	15.87	15.86	7.25	6.38	5.44	5.09	9.95	9.82	22.58	19.73	19.73	50.80	51.92	50.84
Total	**4962.72**	**4960.74**	**4959.75**	**1481.99**	**1304.15**	**1111.49**	**1233.52**	**2525.98**	**2503.71**	**2610.86**	**1999.53**	**1998.33**	**10289.08**	**10790.40**	**10573.28**
Tons CO															
Alabama	183.30	181.06	179.93	1940.09	1862.49	1610.28	1397.57	2371.75	2349.45	725.70	676.53	676.53	4246.66	5091.82	4816.20
Arkansas	101.73	100.18	99.40	874.73	839.74	726.03	865.72	1463.70	1446.58	239.12	231.54	231.54	2081.30	2635.16	2503.56
Florida	5.59	5.51	5.48	441.77	424.10	366.67	472.84	886.54	880.14	42.57	41.21	41.21	962.77	1357.37	1293.50
Georgia	175.75	174.93	174.52	2221.89	2133.02	1844.17	2240.02	3287.28	3252.74	234.53	222.30	222.30	4872.19	5817.53	5493.73
Illinois	22.61	22.48	22.42	845.41	811.60	701.69	767.35	1101.67	1090.26	77.36	74.12	73.85	1712.73	2009.86	1888.22
Indiana	40.78	39.78	39.28	1174.57	1127.59	974.89	799.97	1107.85	1091.45	349.96	199.41	199.41	2365.28	2474.63	2305.03
Kansas	143.24	140.14	138.60	831.69	798.42	690.30	1177.15	1648.56	1626.98	229.16	215.06	214.77	2381.23	2802.18	2670.65
Kentucky	178.47	174.86	173.06	1584.10	1520.74	1314.81	1059.83	1787.30	1766.95	266.27	255.69	255.40	3088.67	3738.59	3510.21
Louisiana	118.62	114.37	112.24	1382.62	1327.32	1147.57	1410.15	2524.08	2499.26	514.87	541.02	541.68	3426.26	4506.78	4300.76
Mississippi	129.94	128.15	127.26	1067.09	1024.41	885.68	814.70	1417.62	1402.66	302.88	302.62	302.40	2314.60	2872.79	2718.00
Missouri	158.95	158.42	158.16	2213.24	2124.72	1837.00	2432.14	3880.30	3845.95	427.91	417.08	417.08	5232.25	6580.52	6258.19
Nebraska	14.32	14.27	14.24	121.88	117.01	101.16	101.12	143.52	142.33	3.73	3.64	3.64	241.05	278.43	261.37
North Carolina	11.68	11.68	11.68	75.54	72.52	62.70	57.87	86.57	85.76	9.64	9.64	9.64	154.73	180.41	169.78
Ohio	54.94	54.66	54.51	567.37	544.68	470.92	897.06	1125.80	1113.82	144.27	139.21	139.02	1663.64	1864.35	1778.28
Oklahoma	78.05	76.82	76.21	1413.87	1357.31	1173.51	2165.04	3501.78	3470.75	712.36	704.55	704.55	4369.31	5640.47	5425.02
South Carolina	0.79	0.79	0.79	23.24	22.31	19.29	5.46	8.71	8.66	0.00	0.00	0.00	29.49	31.81	28.73
Tennessee	255.26	253.54	252.68	2117.62	2032.91	1757.62	1644.00	2681.37	2648.80	319.25	326.36	326.36	4336.12	5294.18	4985.46
Virginia	5.33	5.26	5.23	38.90	37.34	32.29	13.43	18.81	18.32	0.38	0.38	0.38	58.05	61.80	56.22
West Virginia	5.34	5.09	4.97	95.17	91.37	78.99	60.67	97.00	95.27	31.56	31.56	31.56	192.75	225.01	210.79
Total	**1684.69**	**1662.00**	**1650.65**	**19030.80**	**18269.58**	**15795.58**	**18382.07**	**29140.21**	**28836.16**	**4631.53**	**4391.91**	**4391.32**	**43729.09**	**53463.71**	**50673.70**

Table 2-7. Gridded biogenic emissions for states other than Texas.

	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug
NOx (tpd)										
Alabama	78	68	64	70	74	77	74	68	67	68
Arkansas	128	96	94	109	126	134	129	103	102	112
Florida	11	10	9	9	10	10	10	9	9	9
Georgia	51	49	45	47	47	49	48	44	45	46
Illinois	338	271	282	343	385	334	303	292	299	333
Indiana	158	112	121	145	164	144	128	120	130	141
Kansas	444	497	613	689	645	574	494	472	549	549
Kentucky	154	108	113	139	160	149	143	118	122	134
Louisiana	111	102	91	98	106	112	116	106	101	103
Mississippi	133	108	99	113	127	133	137	116	110	118
Missouri	245	215	242	300	314	294	250	235	250	270
Nebraska	148	176	221	226	211	192	170	175	194	192
North Carolina	2	1	1	1	2	1	2	1	1	1
Ohio	22	17	18	20	25	20	19	17	18	20
Oklahoma	196	195	220	238	232	233	202	187	208	216
South Carolina	0	0	0	0	0	0	0	0	0	0
Tennessee	122	86	87	107	120	122	118	93	94	103
Virginia	1	1	0	1	1	1	1	0	0	1
West Virginia	0	0	0	0	1	0	0	0	0	0
Total	**2342**	**2112**	**2322**	**2656**	**2750**	**2581**	**2342**	**2158**	**2301**	**2415**
VOC (tpd)										
Alabama	14097	11687	10261	11937	12969	14092	12878	11027	10796	10584
Arkansas	11291	7772	7543	9151	11323	12454	11394	8109	8074	9278
Florida	2772	2287	2158	2335	2424	2413	2501	2227	2391	2268
Georgia	5614	5244	4760	5001	5229	5973	5539	4163	4471	4451
Illinois	1692	982	1211	1758	1987	1250	1215	1236	1343	1558
Indiana	1395	554	823	1163	1421	999	837	747	910	1067
Kansas	973	1127	1674	2129	1944	1678	1204	1015	1365	1136
Kentucky	3596	1383	1808	2922	3641	2991	2727	1654	2109	2645
Louisiana	9282	8317	6817	7615	8392	8981	9574	8468	7649	7784
Mississippi	14325	10911	9068	11206	12666	13599	13921	11249	10355	11261
Missouri	7786	5601	7350	10521	11716	10253	7380	6513	7538	8222
Nebraska	143	225	345	363	330	276	212	225	266	218
North Carolina	602	497	414	512	568	547	565	367	356	388
Ohio	210	86	113	170	234	163	122	110	133	423
Oklahoma	6505	5351	5630	6046	6717	7195	6392	4891	5089	5953
South Carolina	105	102	83	90	95	111	107	70	72	83
Tennessee	8016	3911	4390	6723	7714	7522	7131	4132	4768	5342
Virginia	98	62	46	91	109	91	82	46	50	71
West Virginia	88	37	38	68	93	66	59	36	47	103
Total	**88590**	**66134**	**64531**	**79801**	**89572**	**90652**	**83840**	**66284**	**67781**	**72836**
CO (tpd)										
Alabama	1349	1141	1014	1143	1231	1328	1223	1092	1068	1073
Arkansas	1030	752	705	834	1019	1132	1030	776	764	859
Florida	354	313	282	301	309	313	312	291	300	295

	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug
Georgia	517	457	411	433	451	495	474	381	391	401
Illinois	166	108	117	155	180	149	136	123	127	146
Indiana	145	82	93	123	147	118	101	90	101	118
Kansas	136	149	205	257	241	210	155	143	176	173
Kentucky	344	196	194	276	337	288	267	195	212	263
Louisiana	953	882	722	791	872	934	1002	885	810	815
Mississippi	1302	1022	847	1011	1142	1232	1246	1036	959	1037
Missouri	610	470	551	742	842	801	594	524	574	630
Nebraska	21	27	39	42	39	33	26	27	32	31
North Carolina	54	44	38	45	48	46	49	36	33	37
Ohio	20	12	12	16	21	15	13	11	13	51
Oklahoma	559	472	489	529	574	624	538	435	470	537
South Carolina	10	9	7	8	8	9	9	7	7	8
Tennessee	692	427	419	584	668	650	621	439	440	480
Virginia	9	7	5	8	10	8	8	5	5	7
West Virginia	8	5	4	6	8	6	5	4	4	11
Total	**8277**	**6575**	**6152**	**7304**	**8146**	**8392**	**7809**	**6499**	**6486**	**6972**



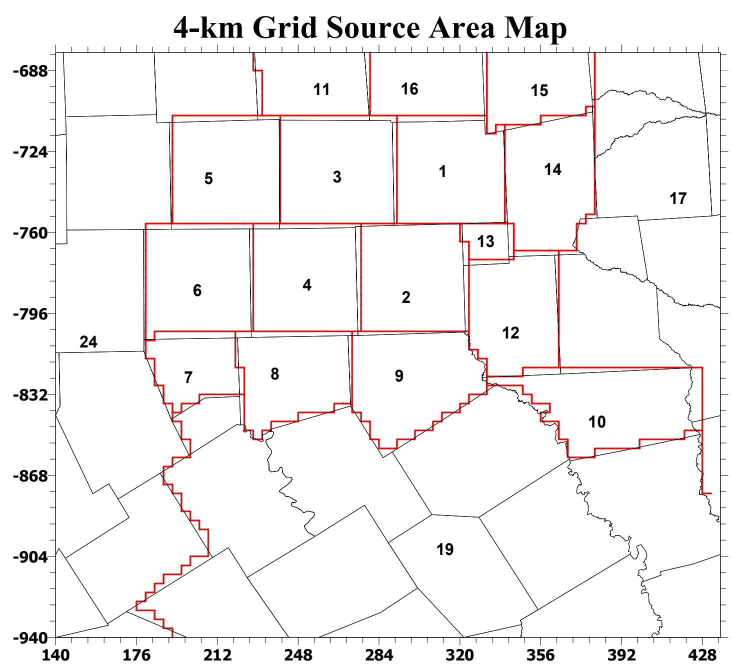


Figure 2-1. Emissions source areas used to prepare the emission summary tables by geographic area. The areas are described in Table 2-8.

Table 2-8. Summary of 1999 model ready emissions for Tuesday August 17th by source region and category.

1999 run17b	Biogenic		On-Road Mobile		All Points		Area + Off-Road Mobile	
Source Region	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
Collin	11.2	29.0	29.2	13.7	5.2	0.7	24.1	23.9
Dallas	4.2	56.2	177.9	76.0	60.7	11.7	82.9	118.0
Denton	8.1	66.4	36.5	15.0	5.2	2.7	18.7	20.0
Tarrant	2.9	65.5	117.5	47.6	40.1	12.5	64.4	82.4
Core	**26.4**	**217.2**	**361.0**	**152.4**	**111.3**	**27.6**	**190.1**	**244.2**
Wise	2.3	149.5	8.1	3.2	11.6	2.0	33.1	20.2
Parker	0.6	130.9	15.0	4.3	4.1	0.9	16.6	11.7
Hood	0.2	34.5	2.0	1.2	30.1	0.3	3.8	4.6
Johnson	4.8	108.3	11.4	4.7	6.0	0.5	9.2	11.1
Ellis	14.3	89.7	19.6	4.7	29.9	6.0	7.8	10.2
Henderson	0.7	275.5	5.8	3.5	5.5	0.6	8.9	12.0
Cooke	3.7	95.4	5.7	2.0	0.0	0.2	3.2	11.6
Kaufman	5.0	105.8	13.4	4.6	0.9	0.8	4.2	10.2
Rockwall	1.6	3.6	4.6	1.7	0.0	0.0	0.9	2.9
Hunt	6.8	77.2	10.9	4.0	0.6	0.1	3.3	10.3
Fannin	7.1	137.0	2.8	1.4	0.0	0.0	1.9	4.7
Grayson	9.1	161.5	16.0	5.7	23.5	0.5	9.9	14.2
Perimeter 12	**56.3**	**1369.0**	**115.1**	**41.2**	**112.1**	**11.9**	**102.6**	**123.6**
Central Texas	113.5	6044.6	152.3	55.6	332.3	40.6	149.0	180.3
Northeast Texas	16.2	4901.6	184.7	79.2	355.6	52.4	143.2	173.2
South Texas	228.6	2109.1	382.2	161.9	457.0	64.3	255.2	431.4
HGBPA	19.9	1772.3	387.1	158.7	704.8	254.0	252.0	296.7
West Texas	525.9	6203.2	282.4	112.2	285.3	38.4	427.8	598.8
AR	132.3	13782.8	232.0	139.6	428.4	93.8	339.1	477.0
LA	108.5	10085.1	377.3	217.8	1177.1	235.9	1023.4	581.6
OK	225.6	7988.2	358.2	240.9	668.0	97.2	397.4	420.7
Other States	1975.7	66127.3	3369.8	2071.2	11844.3	2148.2	3278.5	5170.5
Total	**3428.9**	**120600.4**	**6202.2**	**3430.5**	**16476.4**	**3064.2**	**6558.3**	**8698.0**

Table 2-9. Summary of 2010 model ready emissions for Tuesday August 17th by source region and category.

2010 run01b	Biogenic		On-Road Mobile		All Points		Area + Off-Road Mobile	
Source Region	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
Collin	11.2	29.0	11.9	7.2	3.0	1.2	14.9	19.0
Dallas	4.2	56.2	62.4	35.2	18.0	12.2	67.8	111.7
Denton	8.1	66.4	14.3	7.7	2.7	1.7	17.9	23.2
Tarrant	2.9	65.5	42.2	23.2	13.0	9.7	54.4	85.8
Core	**26.4**	**217.2**	**130.9**	**73.3**	**36.7**	**24.8**	**155.0**	**239.7**
Wise	2.3	149.5	3.4	1.6	10.7	2.0	18.0	18.4
Parker	0.6	130.9	5.0	1.9	4.1	1.0	5.1	13.0
Hood	0.2	34.5	0.9	0.7	20.3	0.6	0.9	5.1
Johnson	4.8	108.3	4.4	2.2	4.4	0.2	7.7	15.5
Ellis	14.3	89.7	6.8	2.1	44.5	6.9	9.0	15.0
Henderson	0.7	275.5	2.7	2.0	6.5	0.6	7.8	14.5
Cooke	3.7	95.4	2.8	0.9	0.0	0.0	2.9	11.2
Kaufman	5.0	105.8	4.9	2.1	6.8	2.0	3.2	14.1
Rockwall	1.6	3.6	2.3	0.8	0.0	0.0	1.0	3.7
Hunt	6.8	77.2	4.0	2.0	0.3	0.1	2.7	15.3
Fannin	7.1	137.0	1.3	0.7	0.0	0.0	1.3	6.3
Grayson	9.1	161.5	6.4	2.6	17.1	0.4	7.9	17.8
Perimeter 12	**56.3**	**1369.0**	**45.0**	**19.5**	**114.7**	**13.9**	**67.4**	**149.9**
Central Texas	113.5	6044.6	64.1	26.2	198.8	26.8	142.2	237.7
Northeast Texas	16.2	4901.6	80.3	33.6	218.8	21.2	127.8	209.8
South Texas	228.6	2109.1	158.5	74.6	321.6	24.4	212.5	457.5
HGBPA	19.9	1772.3	139.6	74.0	296.3	106.9	174.6	279.7
West Texas	525.9	6203.2	131.2	56.5	228.2	19.8	397.2	661.0
AR	132.3	13782.8	117.2	59.6	385.6	124.0	312.2	363.8
LA	108.5	10085.1	180.6	96.2	1044.7	248.3	970.5	385.3
OK	225.6	7988.2	175.2	100.6	683.4	167.3	243.9	301.5
Other States	1975.7	66127.3	1784.4	980.8	6222.5	1785.1	3274.0	3822.6
Total	**3428.9**	**120600.4**	**3007.0**	**1595.0**	**9751.1**	**2562.3**	**6077.4**	**7108.3**

Table 2-10. Ratio of 2010 to 1999 model ready emissions for Tuesday August 17th by source region and category.

2010/1999	Biogenic		On-Road Mobile		All Points		Area + Off-Road Mobile	
Source Region	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
Collin	1.00	1.00	0.41	0.52	0.57	1.59	0.62	0.80
Dallas	1.00	1.00	0.35	0.46	0.30	1.04	0.82	0.95
Denton	1.00	1.00	0.39	0.51	0.52	0.65	0.96	1.16
Tarrant	1.00	1.00	0.36	0.49	0.32	0.78	0.84	1.04
Core	**1.00**	**1.00**	**0.36**	**0.48**	**0.33**	**0.90**	**0.82**	**0.98**
Wise	1.00	1.00	0.42	0.50	0.93	0.98	0.54	0.91
Parker	1.00	1.00	0.33	0.43	1.01	1.09	0.31	1.11
Hood	1.00	1.00	0.46	0.55	0.67	2.02	0.24	1.11
Johnson	1.00	1.00	0.39	0.47	0.73	0.44	0.84	1.40
Ellis	1.00	1.00	0.35	0.44	1.49	1.16	1.15	1.48
Henderson	1.00	1.00	0.47	0.56	1.18	0.96	0.87	1.21
Cooke	1.00	1.00	0.49	0.45	0.55	0.24	0.91	0.96
Kaufman	1.00	1.00	0.37	0.46	7.91	2.39	0.77	1.39
Rockwall	1.00	1.00	0.50	0.44	0.00	0.00	1.07	1.26
Hunt	1.00	1.00	0.37	0.50	0.41	1.18	0.81	1.49
Fannin	1.00	1.00	0.45	0.48	0.00	0.00	0.69	1.34
Grayson	1.00	1.00	0.40	0.47	0.73	0.80	0.80	1.25
Perimeter 12	**1.00**	**1.00**	**0.39**	**0.47**	**1.02**	**1.16**	**0.66**	**1.21**
Central Texas	1.00	1.00	0.42	0.47	0.60	0.66	0.95	1.32
Northeast Texas	1.00	1.00	0.44	0.42	0.62	0.40	0.89	1.21
South Texas	1.00	1.00	0.41	0.46	0.70	0.38	0.83	1.06
HGBPA	1.00	1.00	0.36	0.47	0.42	0.42	0.69	0.94
West Texas	1.00	1.00	0.46	0.50	0.80	0.52	0.93	1.10
AR	1.00	1.00	0.51	0.43	0.90	1.32	0.92	0.76
LA	1.00	1.00	0.48	0.44	0.89	1.05	0.95	0.66
OK	1.00	1.00	0.49	0.42	1.02	1.72	0.61	0.72
Other States	1.00	1.00	0.53	0.47	0.53	0.83	1.00	0.74
Total	**1.00**	**1.00**	**0.48**	**0.46**	**0.59**	**0.84**	**0.93**	**0.82**

Table 2-11. Emissions source area definitions.

Area Number	Area Abbreviation	Area Definition
1-4	Core	Dallas Core Counties (Collin, Dallas, Denton, Tarrant)
5-16	Perimeter12	12 Counties surrounding Dallas Core (Wise, Parker, Hood Johnson, Ellis, Henderson, Cooke, Kaufman, Rockwall, Hunt, Fannin, Grayson)
17	Northeast Texas	Northeast Texas
18	HGBPA	Houston/Galveston/Beaumont/Port-Arthur (11 Counties)
19	Central Texas	East Central Texas
20	OK	Oklahoma
21	AR	Arkansas
22	LA	Louisiana
23	South Texas	Near Non-attainment areas (Austin, San Antonio, Victoria, Corpus Christi)
24	West Texas	Texas (excluding area 1-19 and 23
25	Other States	Other areas

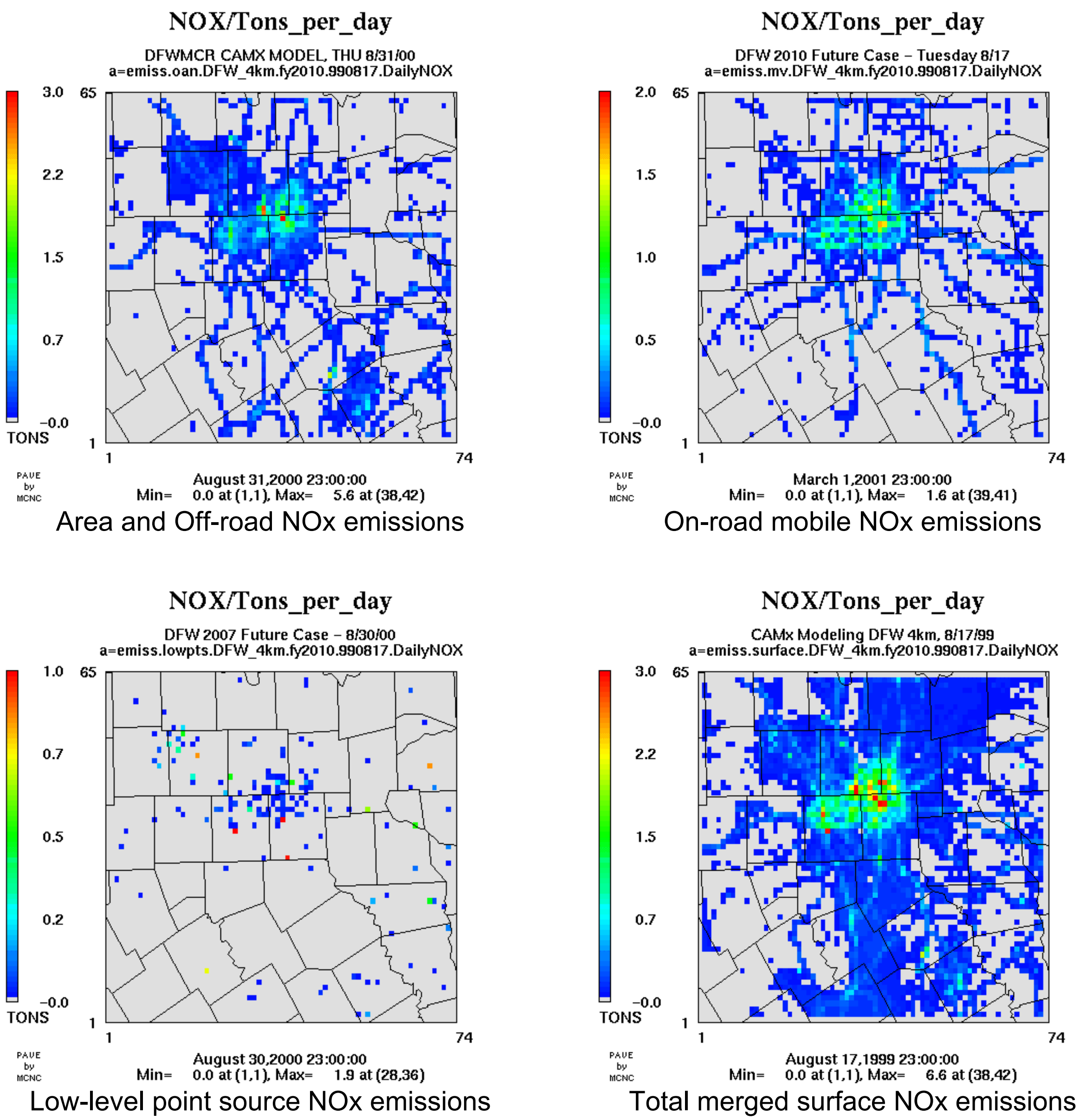


Figure 2-2. 2010 NOx emissions for Tuesday August 17th on the 4-km grid.

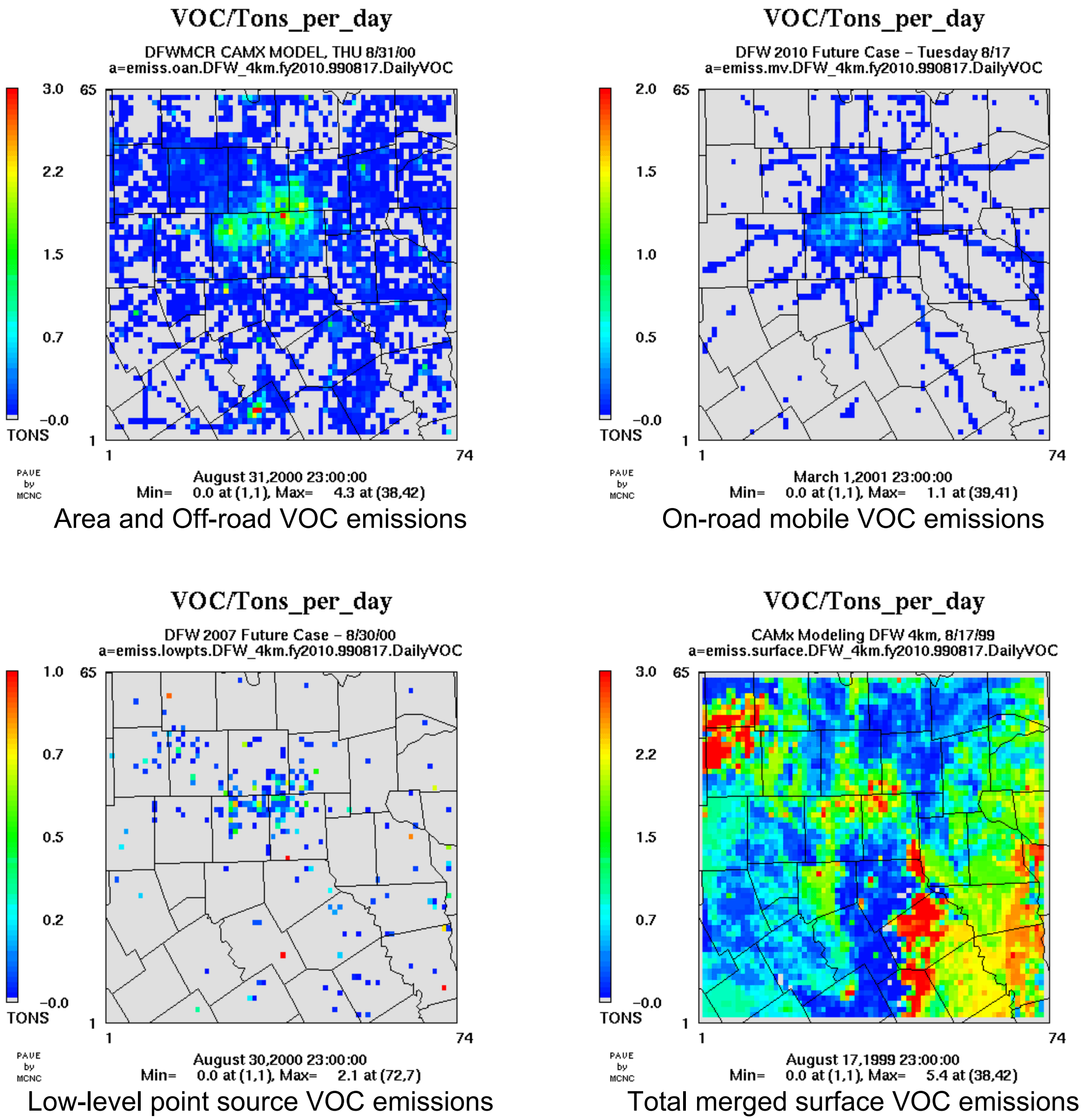
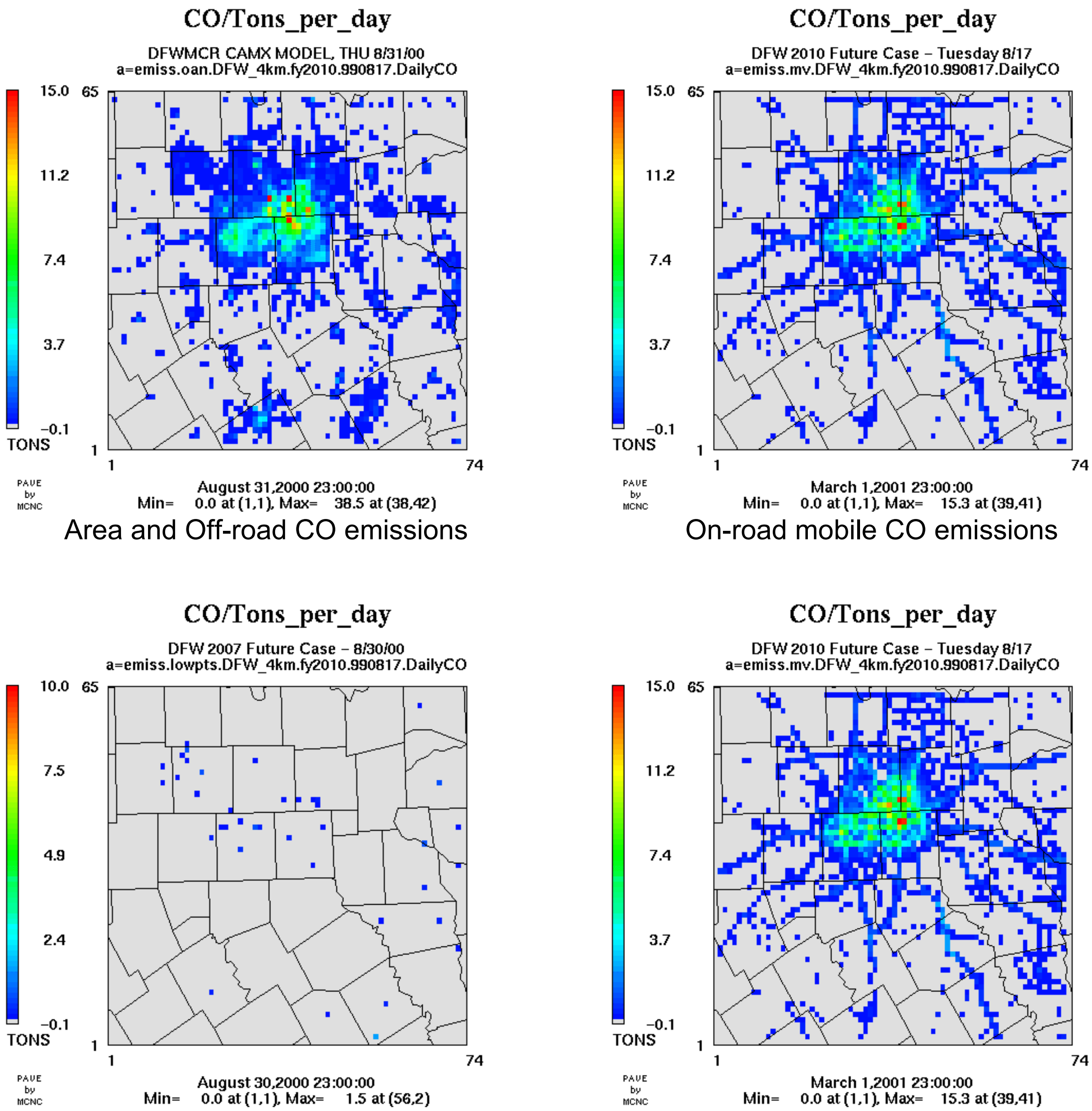


Figure 2-3. 2010 VOC emissions for Tuesday August 17th on the 4-km grid.



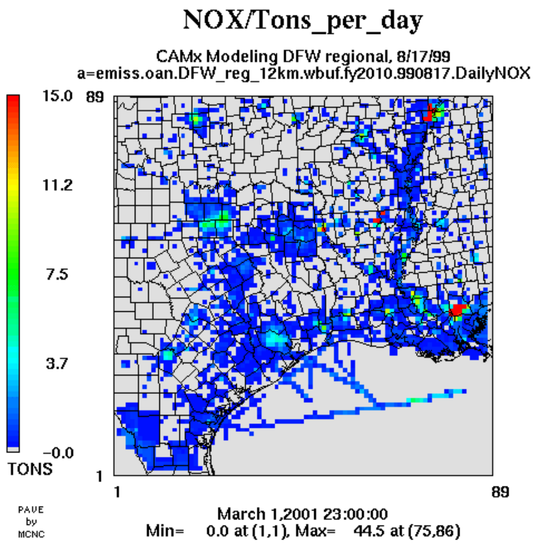
Area and Off-road CO emissions

On-road mobile CO emissions

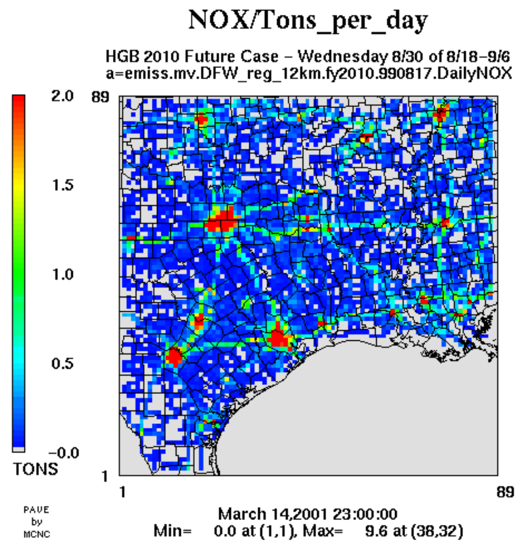
Low-level point source CO emissions

Total merged surface CO emissions

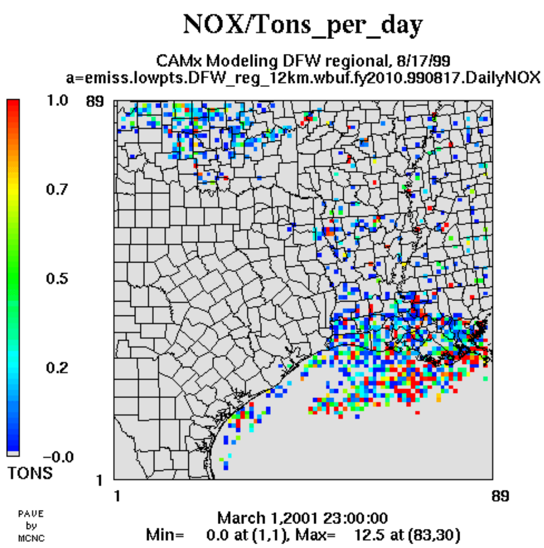
Figure 2-4. 2010 CO emissions for Tuesday August 17th on the 4-km grid.



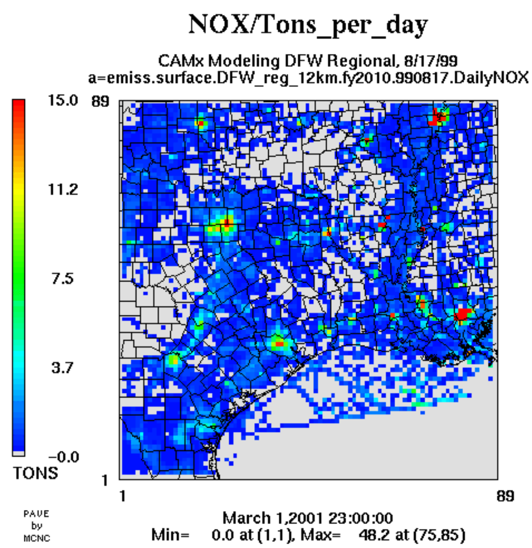
Area and Off-road NOx emissions



On-road mobile NOx emissions



Low-level point source NOx emissions



Total merged surface NOx emissions

Figure 2-5. 2010 NOx emissions for Tuesday August 17th on the 12-km emissions grid.

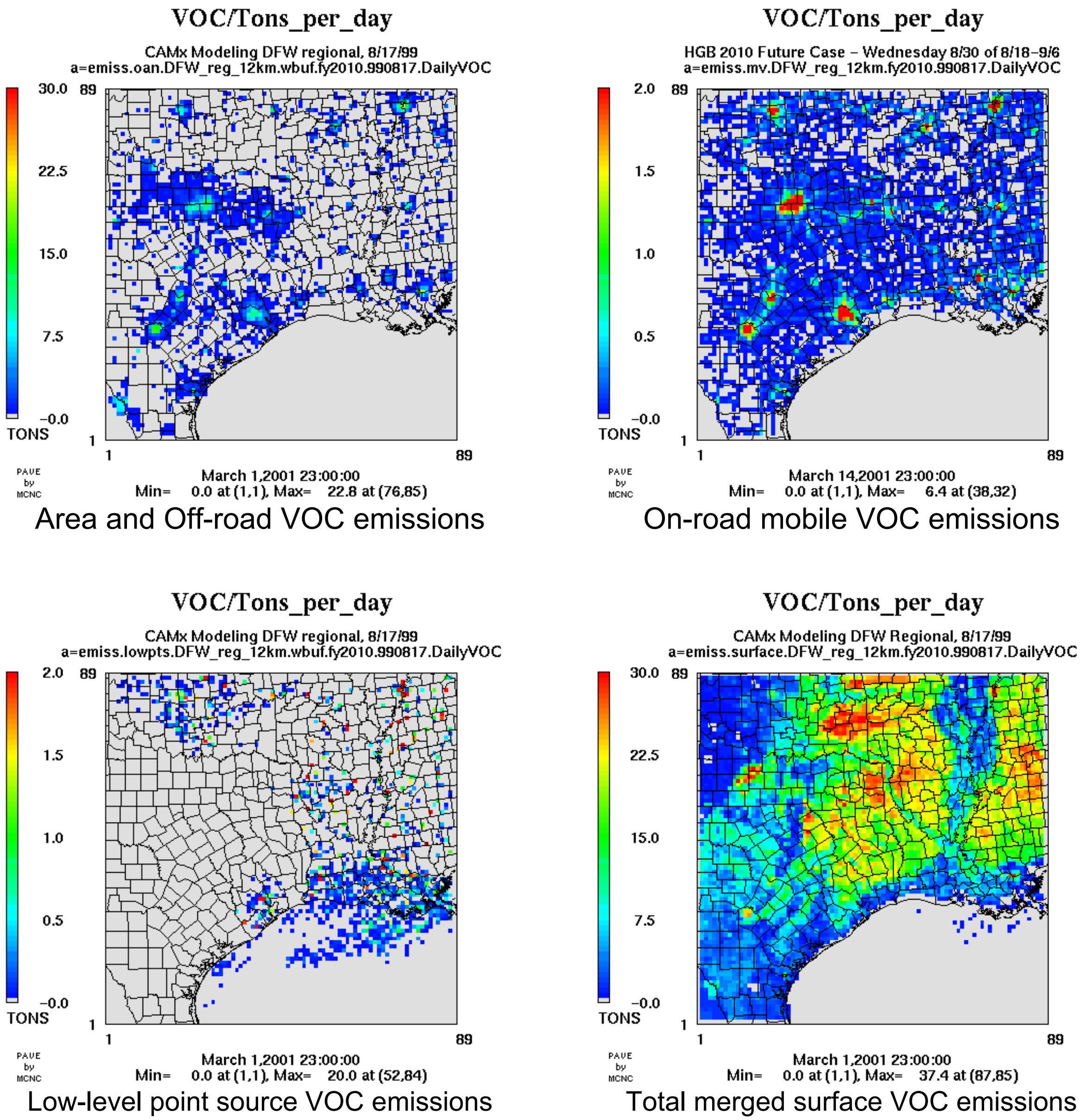
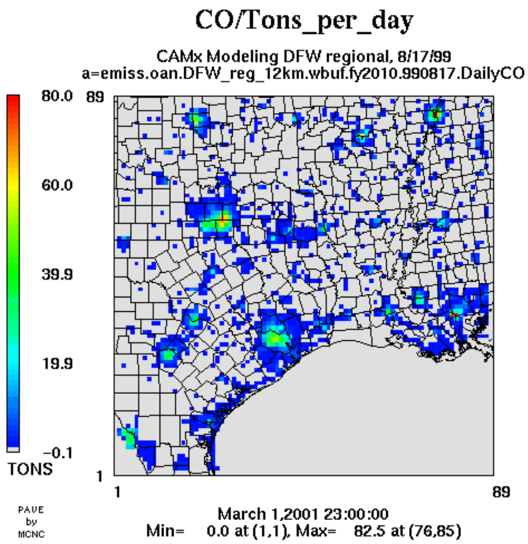
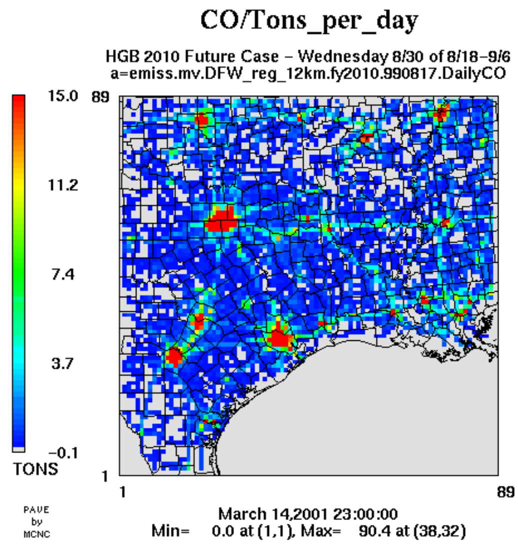


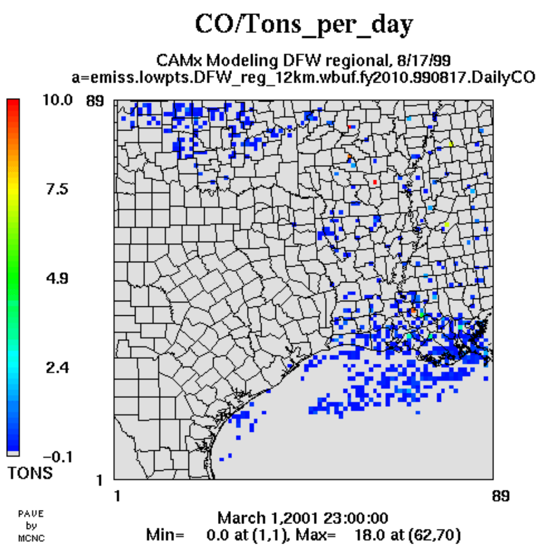
Figure 2-6. 2010 VOC emissions for Tuesday August 17th on the 12-km emissions grid.



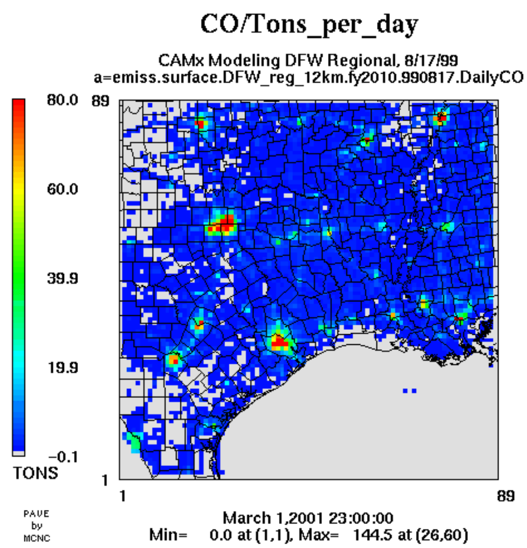
Area and Off-road CO emissions



On-road mobile CO emissions



Low-level point source CO emissions



Total merged surface CO emissions

Figure 2-7. 2010 CO emissions for Tuesday August 17th on the 12-km emissions grid.

3.0 OZONE MODELING

CAMx MODEL CONFIGURATION AND INPUTS

Previous CAMx modeling of the Dallas/Fort Worth August 1999 ozone episode described by Mansell et al. (2003) used version 4.02 of the CAMx model. The current 2007 future year modeling uses CAMx version 4.03. CAMx 4.03 includes only a few changes from CAMx 4.02 (see the model release notes posted at http://www.camx.com), but one change corrects an error in the calculation of dry deposition velocities and results in slightly lower ozone levels (a few ppb) with CAMx 4.03 than CAMx 4.02 for the DFW modeling. The 1999 base year modeling was re-run with CAMx 4.03 to provide consistent base and future year simulation results for subsequent analysis. The input data format requirements are the same for CAMx versions 4.02 and 4.03 so that updating the 1999 modeling to the new CAMx version does not require any changes to input data or files.

All of the meteorological input data for the CAMx simulations were derived from the Fifth Generation Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5; Duhdia, 1993). The MM5 modeling used nested 108-km, 36-km, 12-km and 4-km grids and 28 vertical layers. An analysis of the meteorological modeling performed in support of the initial 1999 DFW air quality modeling efforts, and the final MM5 run used for air quality modeling of the DFW 1999 episode (denoted Run3), is documented in ENVIRON, 2003, and Mansell et al., (2003).

Additional MM5 modeling was performed under contract to TCEQ with the goal of improving the meteorological modeling and subsequent air quality modeling results. These efforts are documented in Emery et al., (2004). The final MM5 run used in the updated 1999 air quality modeling simulations, as well as the 2010 future year CAMx simulations documented herein, is denoted Run5.

CAMx has several user-selectable options that are specified for each simulation through the CAMx control file. Most of these options follow naturally from other choices about model inputs. There are four model options that must be decided for each project: the choice of the chemical mechanism, the chemistry solver, advection scheme, and the plume-in-grid scheme. The selection for each option is decided at the stage of the base case model performance evaluation and then held fixed for the evaluation of any future year emission scenarios. The CAMx model configuration and inputs used for both the 1999 and 2007 modeling were documented in Mansell, et al., (2003), and briefly summarized below.

Chemistry Data

The chemistry parameters file specifies the photochemical mechanism used to model ozone formation as well as the rates for all thermo-chemical reactions associated with the chemical mechanism.

- CAMx was run with an updated version of the Carbon Bond 4 mechanism (CB4), referred to as mechanism 3 in CAMx, which is described in the CAMx User's Guide (ENVIRON, 2002). Mechanism 3 is the CB4 mechanism with updated radical-radical termination reactions and updated isoprene mechanism as used for the OTAG modeling and other TCEQ modeling studies.

- CAMx has two options for the numerical scheme used to solve the chemical mechanism. The first option is the CMC fast solver that has been used in every prior version of CAMx. The second option is an IEH solver. The CMC solver is faster and more accurate than most chemistry solvers used for ozone modeling. The IEH solver is even more accurate than the CMC solver, but slower. The CMC solver was used for this study.

- The CB4 mechanism also includes several "photolysis" reactions that depend upon the presence of sunlight. The photolysis rates input file determines the rates for chemical reactions in the mechanism that are driven by sunlight. Photolysis rates were calculated using the Tropospheric visible Ultra-Violet (TUV) model developed by the National Center for Atmospheric Research (Madronich, 1993 and 2002). TUV is a state-of-the-science solar radiation model that is designed for photolysis rate calculations. TUV accounts for environmental parameters that influence photolysis rates including solar zenith angle, altitude above the ground, surface UV albedo, aerosols (haze), and stratospheric ozone column.

Advection Scheme

CAMx version 4.03 has three optional methods for calculating horizontal advection called Smolarkiewicz, Bott and Piecewise Parabolic Method (PPM). Although the Smolarkiewicz scheme has been used for many years, and was used in the previous modeling for Northeast Texas (ENVIRON, 1999), the scheme has been criticized for causing too much artificial diffusion of pollutants, tending to "smear out" features and artificially overstate transport. The Bott and PPM schemes are newer and have less artificial diffusion than the Smolarkiewicz scheme. The PPM scheme was used for this study as it has been determined to be the least numerically diffusive, runs at speeds similar to Smolarkiewicz, and does not exhibit certain "noisy" features near sharp gradients that are apparent with the Bott approach.

Plume-in-Grid

CAMx includes an optional sub-grid scale plume model that can be used to represent the dispersion and chemistry of major NOx point source plumes close to the source. We used the Plume-in-Grid (PiG) sub-model for major NOx sources (i.e., point sources with episode average NOx emissions greater than 2 tons per day in the 4-km grid and 2.5 tons per day outside the 4-km grid).

Surface Characteristics

CAMx requires gridded landuse data to characterize surface boundary conditions, such as surface roughness, deposition parameters, vegetative distribution, and water/land boundaries. CAMx land use files provide the fractional contribution (0 to 1) of eleven land use categories to the surface area of grid cell. Gridded land cover data were developed from the same landuse databases that were used in the generation of spatial emission surrogates for the 36-km and 12-km grids. The development of surface characteristics data was documented in Mansell et al. (2003).

Initial and Boundary Conditions

The initial conditions (ICs) are the pollutant concentrations specified throughout the modeling domain at the start of the simulation. Boundary conditions (BCs) are the pollutant concentrations specified at the perimeter of the modeling domain. Conventional wisdom dictates that the boundary conditions should have little impact on the model results for the DFW area because regional scale modeling is being performed. One of the reasons for performing regional scale modeling rather than urban scale modeling is to minimize the importance of ICs and BCs. Using a large regional domain moves the boundaries far away (in distance and transport time) from the study area, theoretically reducing the influence of these conditions.

However, the base case modeling and sensitivity tests (Mansell et al., 2003) showed that even with the large regional domain (Fig. 1-1), the boundary conditions do influence the modeling results for DFW non-attainment area. In particular, the amount of background VOC in air entering the modeling domain from the Midwest and Southeast influences the regional background ozone levels transported into DFW. The VOC boundary conditions are mainly influenced by biogenic emissions and so there is no reason to reduce the VOC boundary conditions from 1999 to 2010. The ozone boundary condition was set to 40 ppb for 1999, which is the commonly assumed default background level for ozone. The NOx boundary condition for 2010 was set to 1.1 ppb, which is a low value representative of rural areas. The 2010 boundary and initial conditions were unchanged from the 1999 values described in Mansell et al. (2003).

UPDATED 1999 BASE CASE

Version 4.03 of the CAMx air quality model was run for the August 1999 Dallas/Ft. Worth ozone episode using the model configuration and input data described above. Both the 1999 base and 2010 future years were simulated. The 1999 base year was re-run with CAMx 4.03 and updated emissions (Emery et al., 2004) to provide a consistent set of modeling results for the design value scaling analysis. Model performance was slightly degraded from the CAMx 4.02 model results as discussed in more detail in Emery et al. (2004).

OZONE MODELING RESULTS FOR 1999 AND 2010

Table 3-1 presents the observed and predicted daily maximum 1-hour ozone concentrations for the 1999 base case (99Run17b) as well as the predicted daily maximum 1-hour ozone concentrations for the 2007 future year simulations (10run01b). The results presented in Table 3-1 are for the DFW 4-km modeling domain. The corresponding observed and predicted daily maximum 8-hour ozone concentrations are presented in Table 3-2.

Table 3-1. One-hour ozone concentrations on the DFW 4-km modeling domain.

		Episode Day							
		8/15/99	8/16/99	8/17/99	8/18/99	8/19/99	8/20/99	8/21/99	8/22/99
Peak Observed (ppb)									
		107.0	127.0	150.0	131.0	128.0	108.0	111.0	100.0
Peak Predicted (ppb)									
	99Run 17b	119.2	129.7	133.4	135.7	131.7	104.0	117.3	117.3
	10Run 01b	99.4	119.6	125.5	119.1	111.4	93.1	101.3	95.2

Table 3-2. Eight-hour ozone concentrations on the DFW 4-km modeling domain.

		Episode Day							
		8/15/99	8/16/99	8/17/99	8/18/99	8/19/99	8/20/99	8/21/99	8/22/99
Peak Observed (ppb)									
		98.0	108.0	126.0	116.0	108.0	98.0	98.0	90.0
Peak Predicted (ppb)									
	99Run 17b	107.2	103.0	108.0	117.6	107.4	94.2	103.7	100.9
	10Run 01b	89.0	97.1	103.7	108.7	96.7	79.6	89.9	85.6

Figures 3-1 and 3-2 present the spatial distribution of predicted 1-hour ozone concentrations within the DFW 4-km and regional 12-km modeling domains, respectively. Results for both the 1999 base and 2010 future year simulations are shown. Also shown is the difference in predicted daily maximum 1-hour ozone concentrations. Only the August 15 – 22 episode days are shown, as the first two days of the episode are considered "spin-up" days.

Corresponding displays for the predicted daily maximum 8-hour ozone concentrations are presented in Figures 3-3 and 3-4.

Examination of the displays on Figures 3-3 and 3-4 reveal similar patterns in the spatial distribution of elevated ozone levels between the 1999 and 2010 base case simulations. Broad regions of reductions in both 1-hour and 8-hour ozone concentrations are seen although there is a fairly large area of ozone disbenefits in the Dallas urban core. These disbenefits range from a few ppb up to approximately 13 ppb ozone for the 8-hour daily maximum in the DFW 4-km modeling domain. On most episode days, the locations of the ozone peaks in 2010 are shifted closer towards the 4-county core area within the DFW non-attainment region. In addition, large ozone increases are evident in the Houston urban area and over the Gulf of Mexico in 2010.

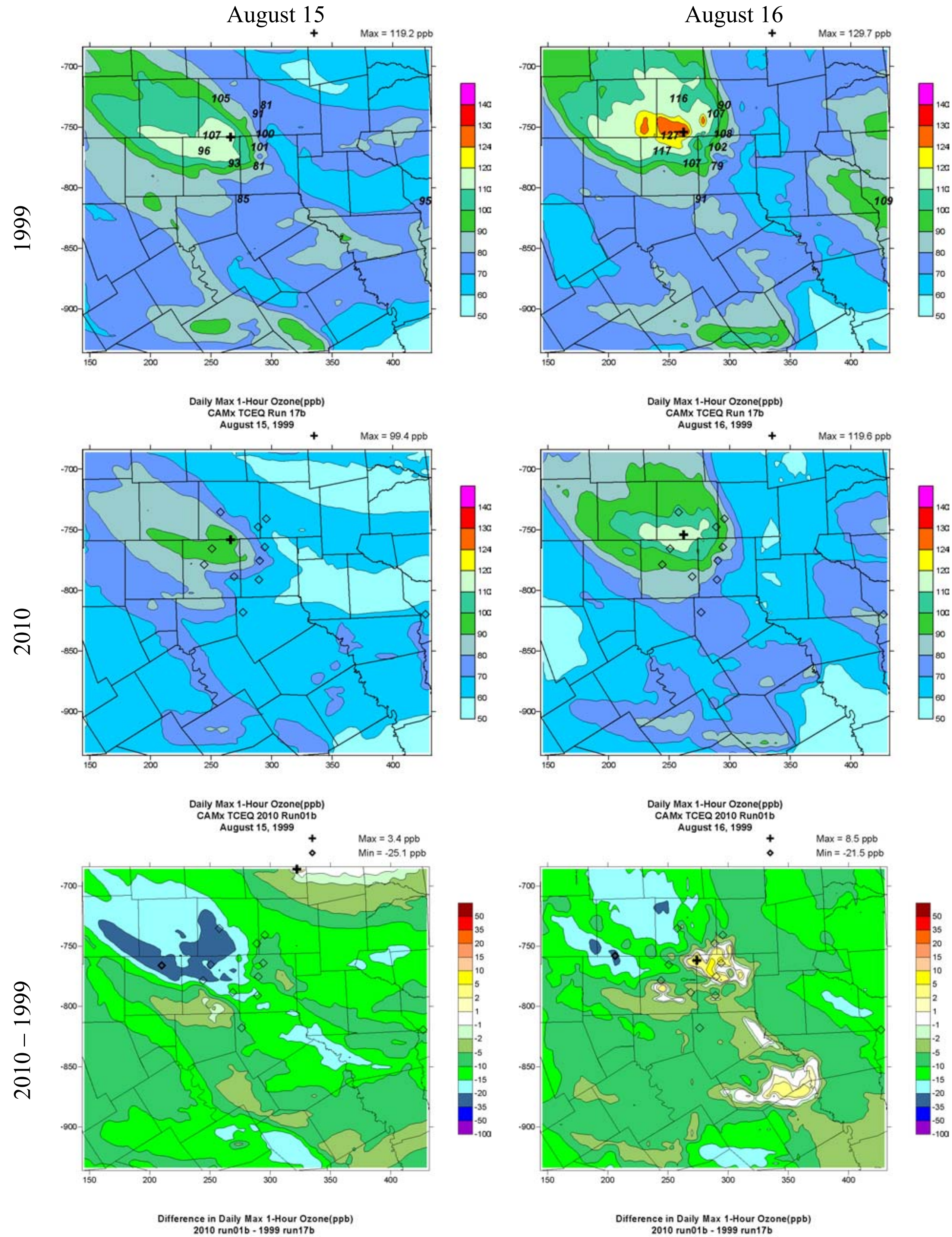


Figure 3-1. Daily maximum 1-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

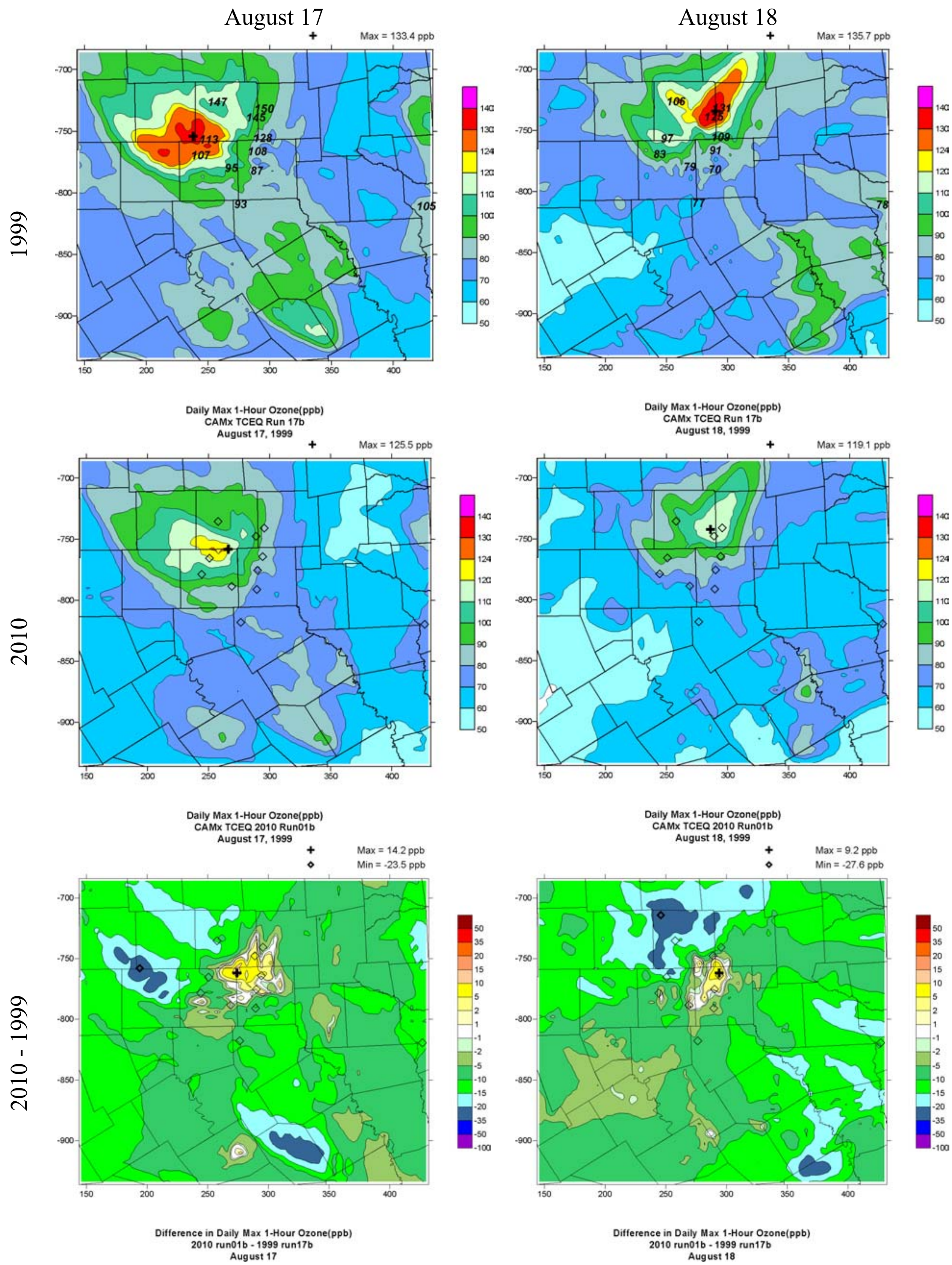


Figure 3-1 (cont.) Daily maximum 1-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

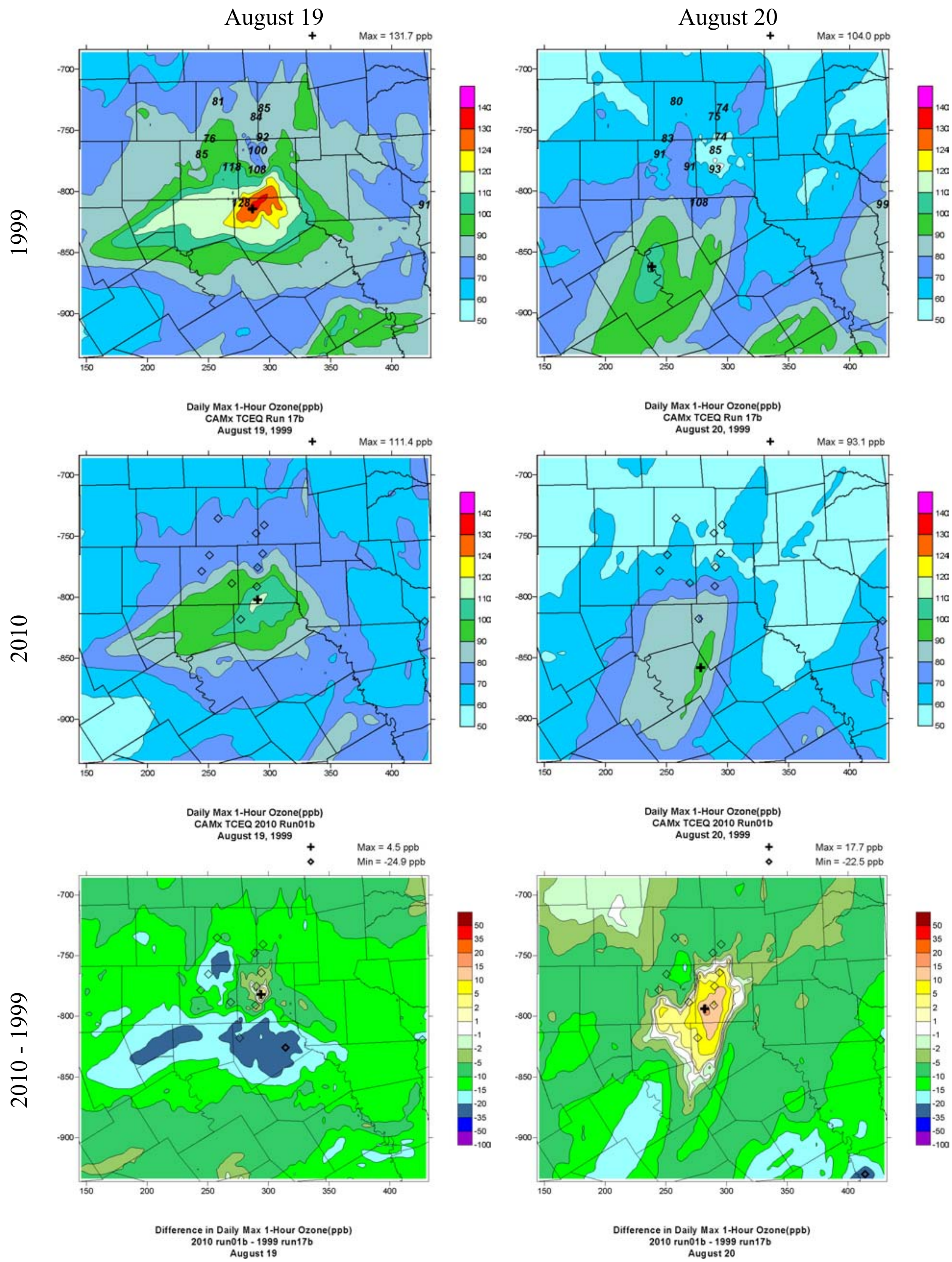


Figure 3-1 (cont.) Daily maximum 1-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

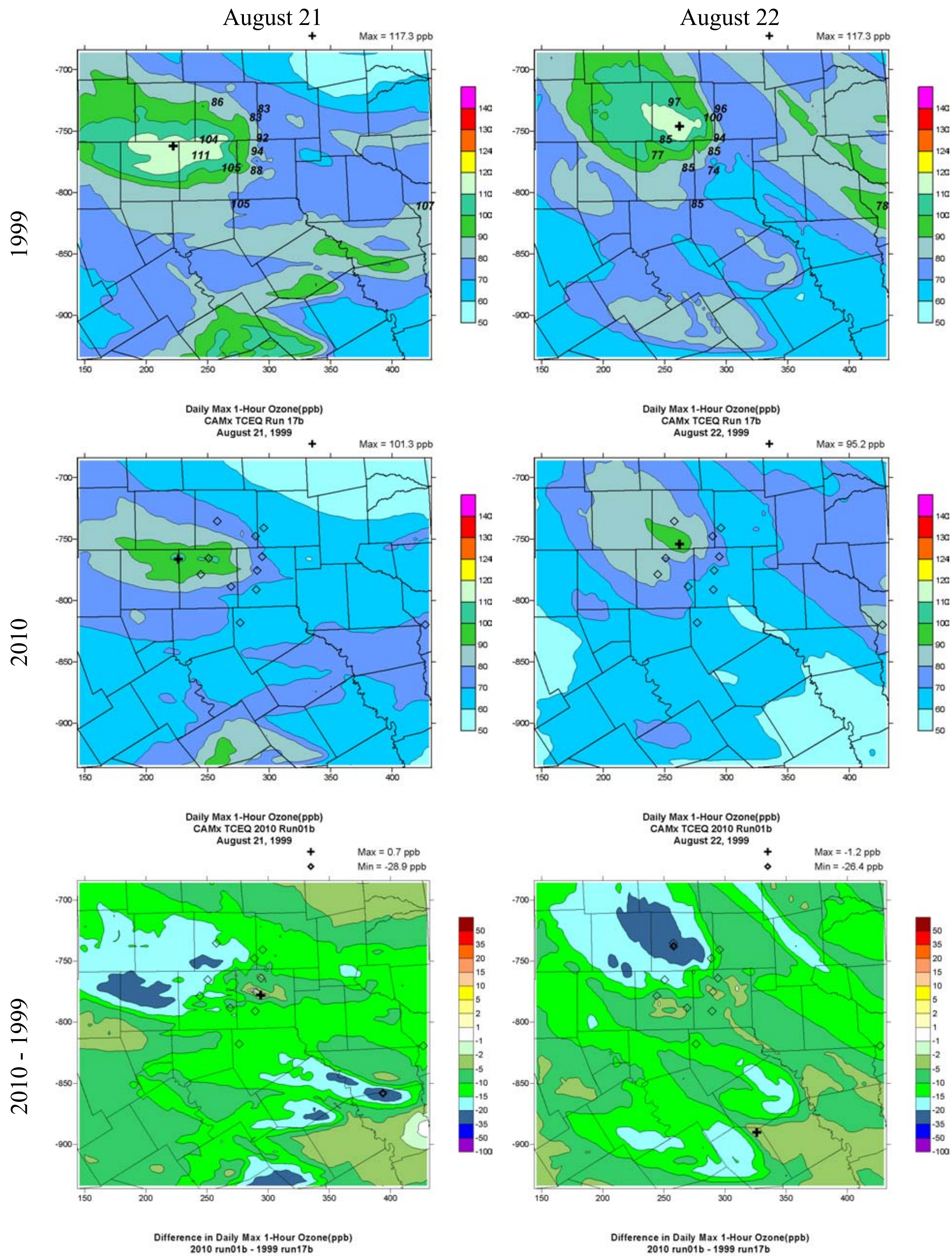


Figure 3-1 (concluded). Daily maximum 1-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

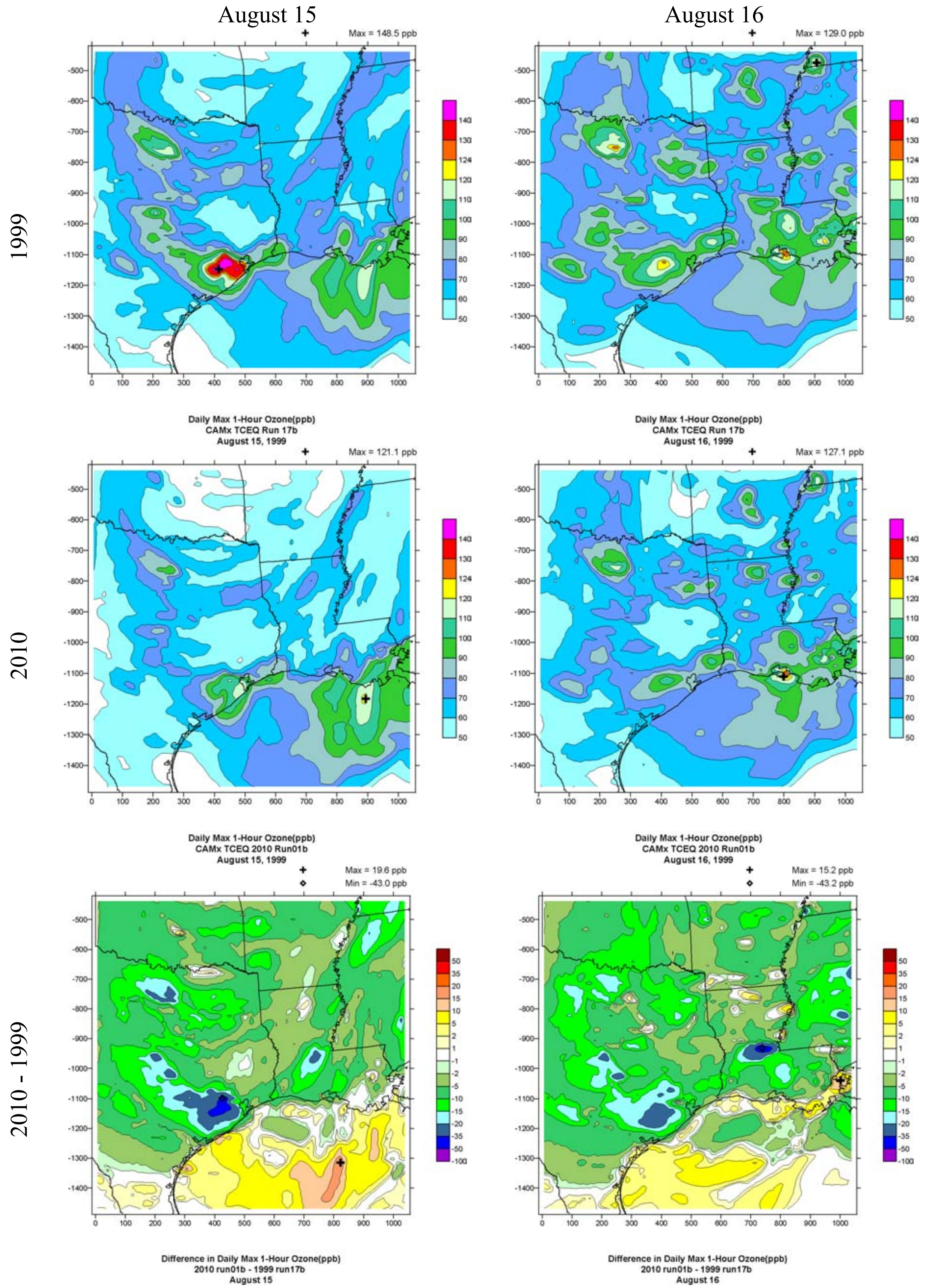


Figure 3-2. Daily maximum 1-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

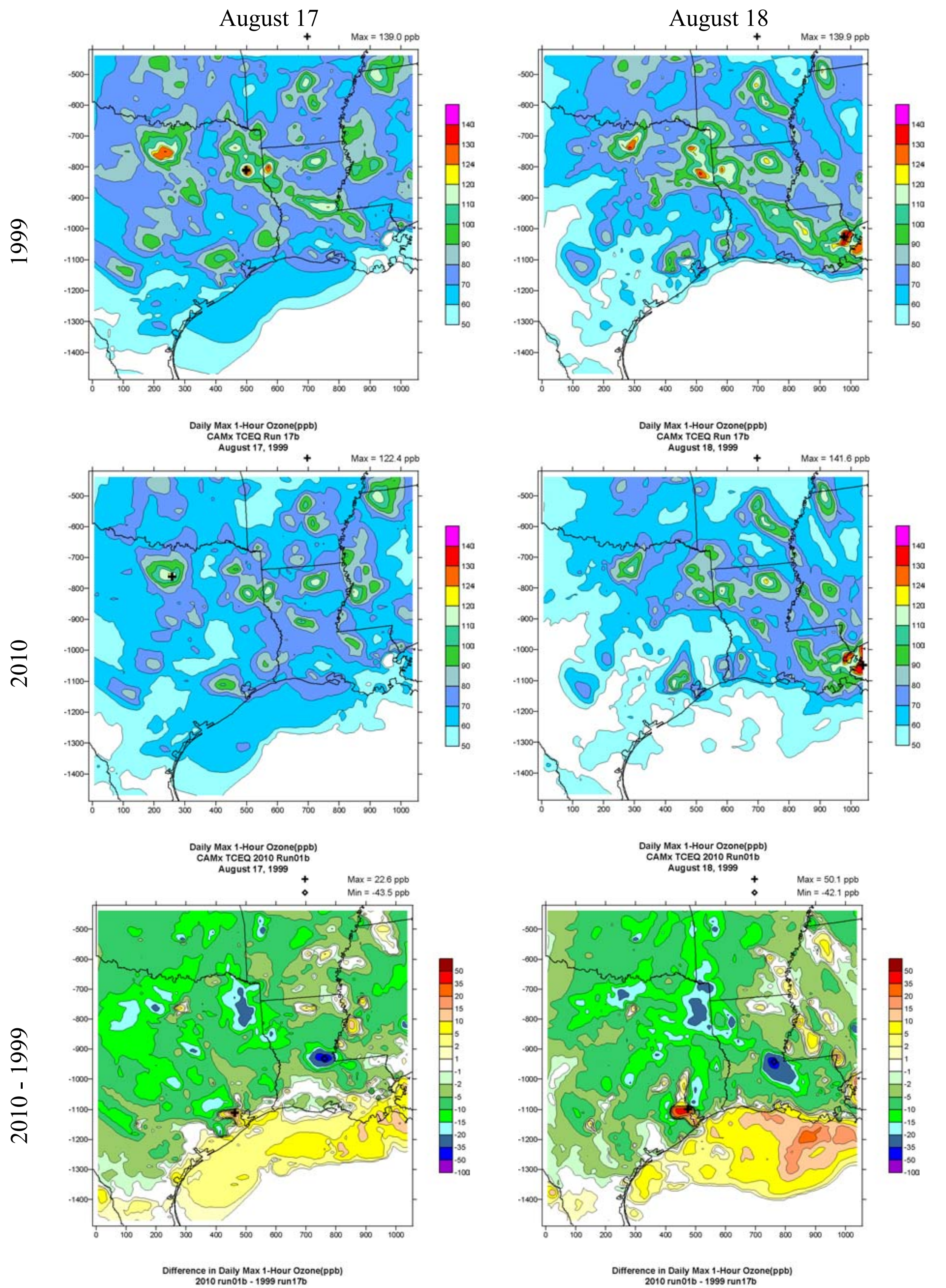


Figure 3-2. Daily maximum 1-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

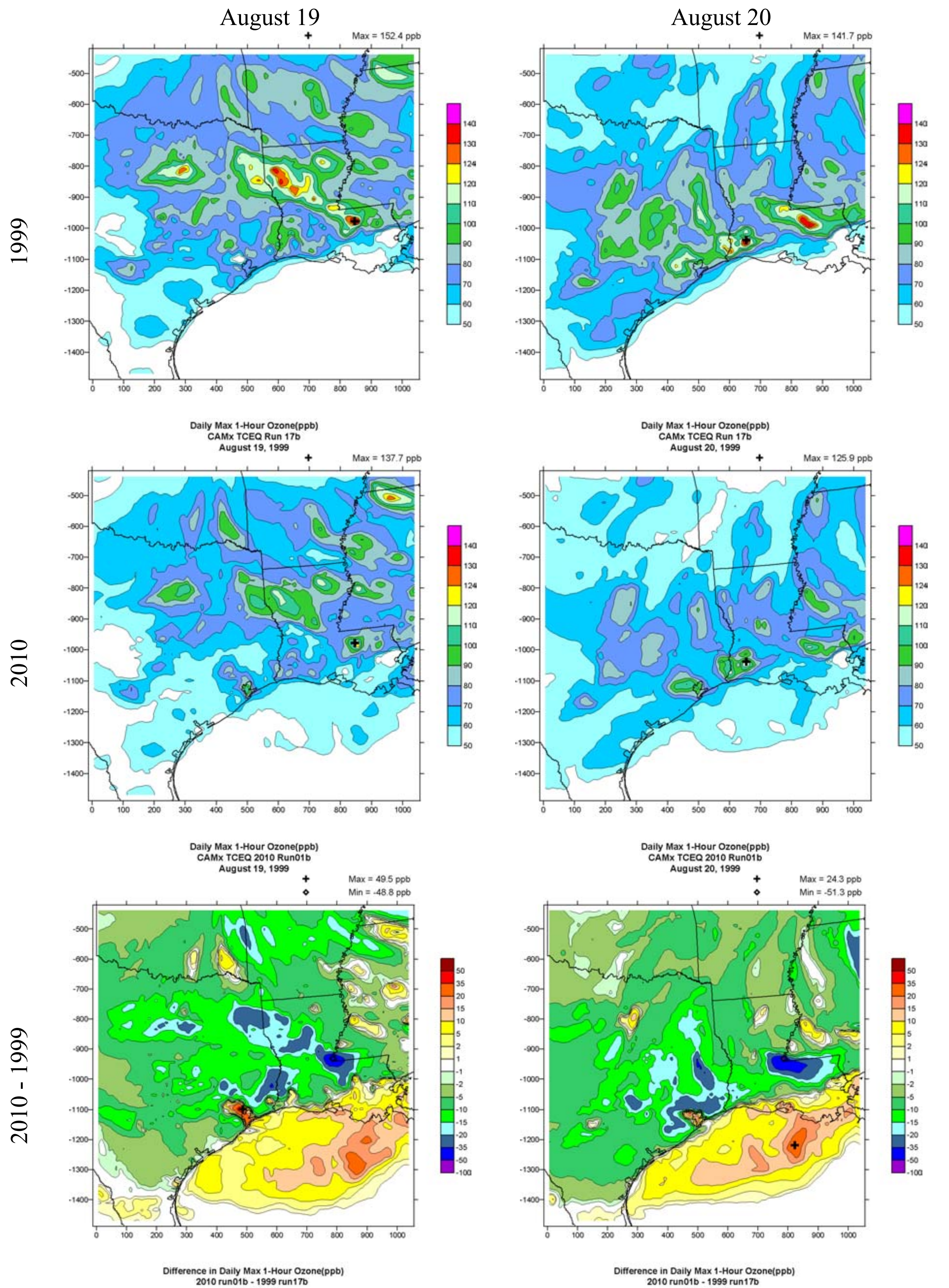


Figure 3-2. Daily maximum 1-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

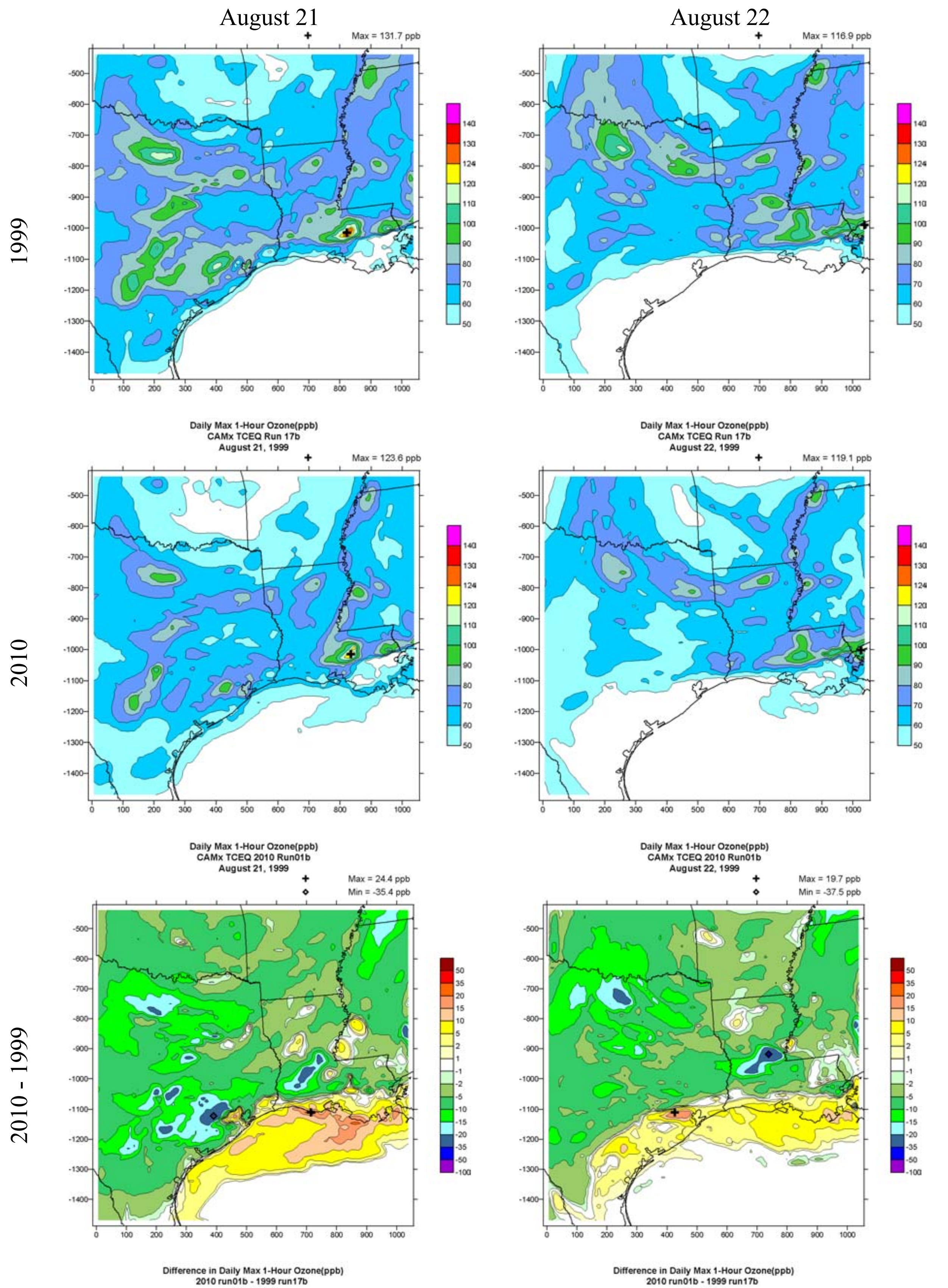


Figure 3-2. Daily maximum 1-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

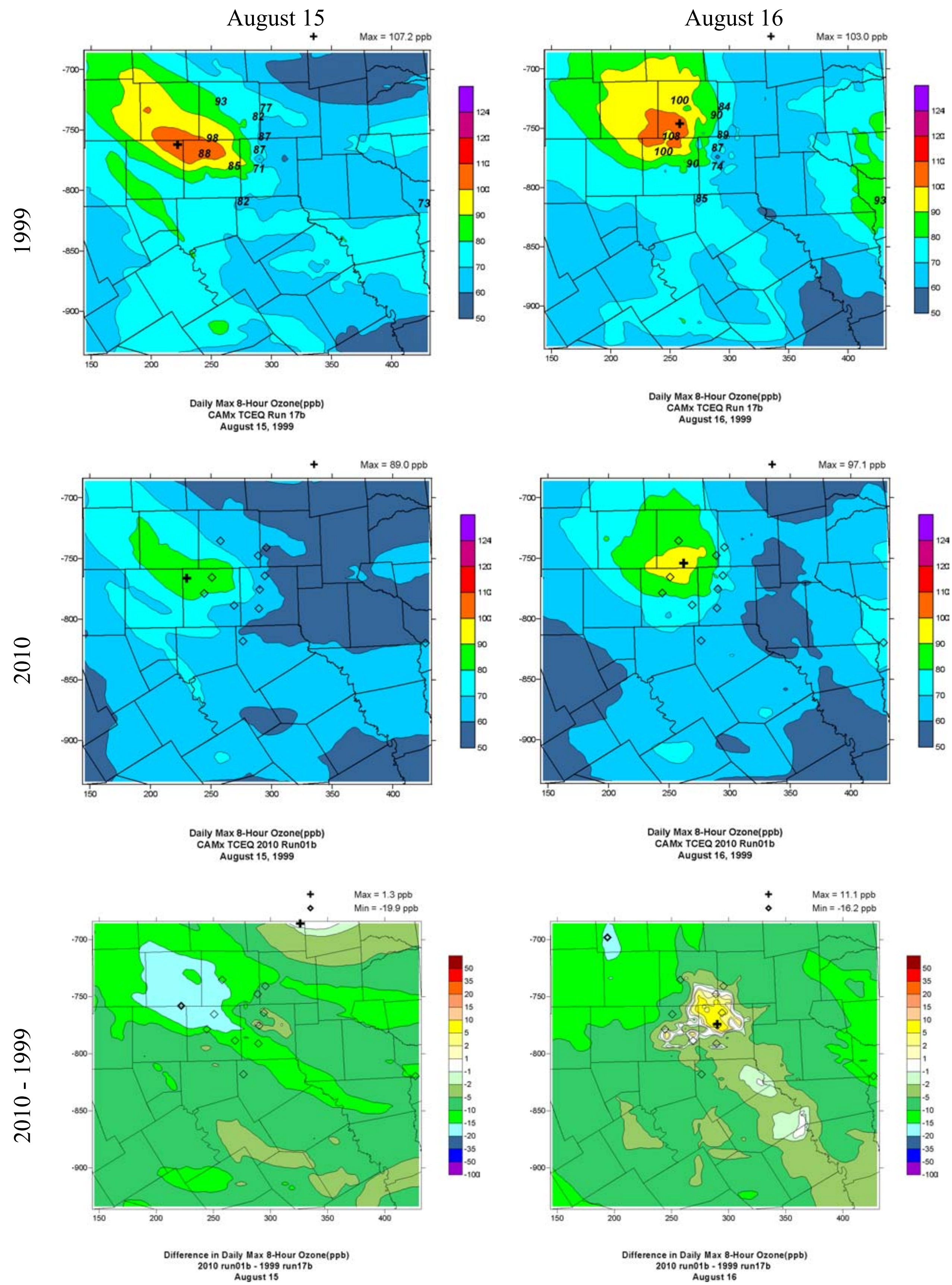


Figure 3-3. Daily maximum 8-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

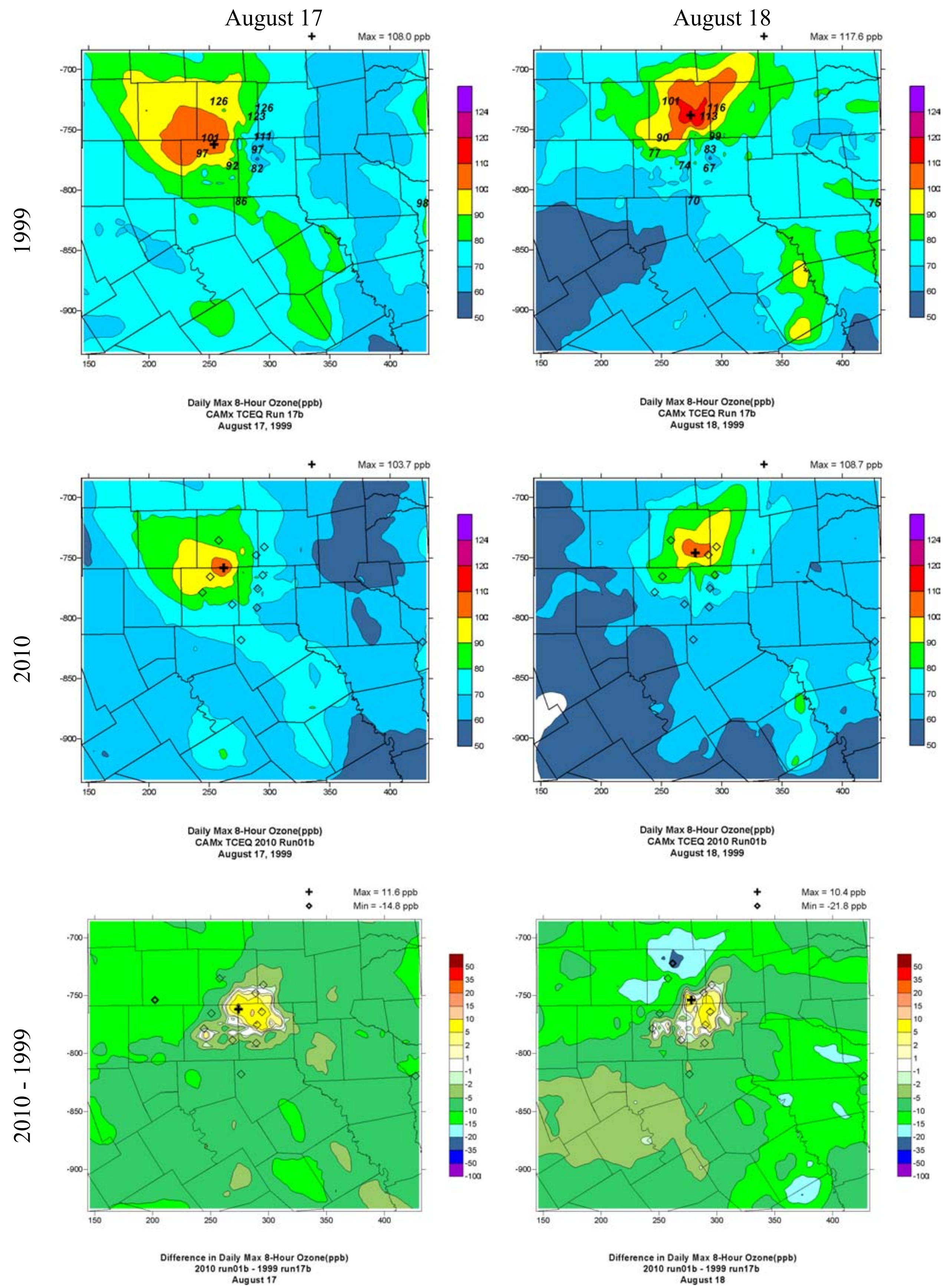


Figure 3-3. Daily maximum 8-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

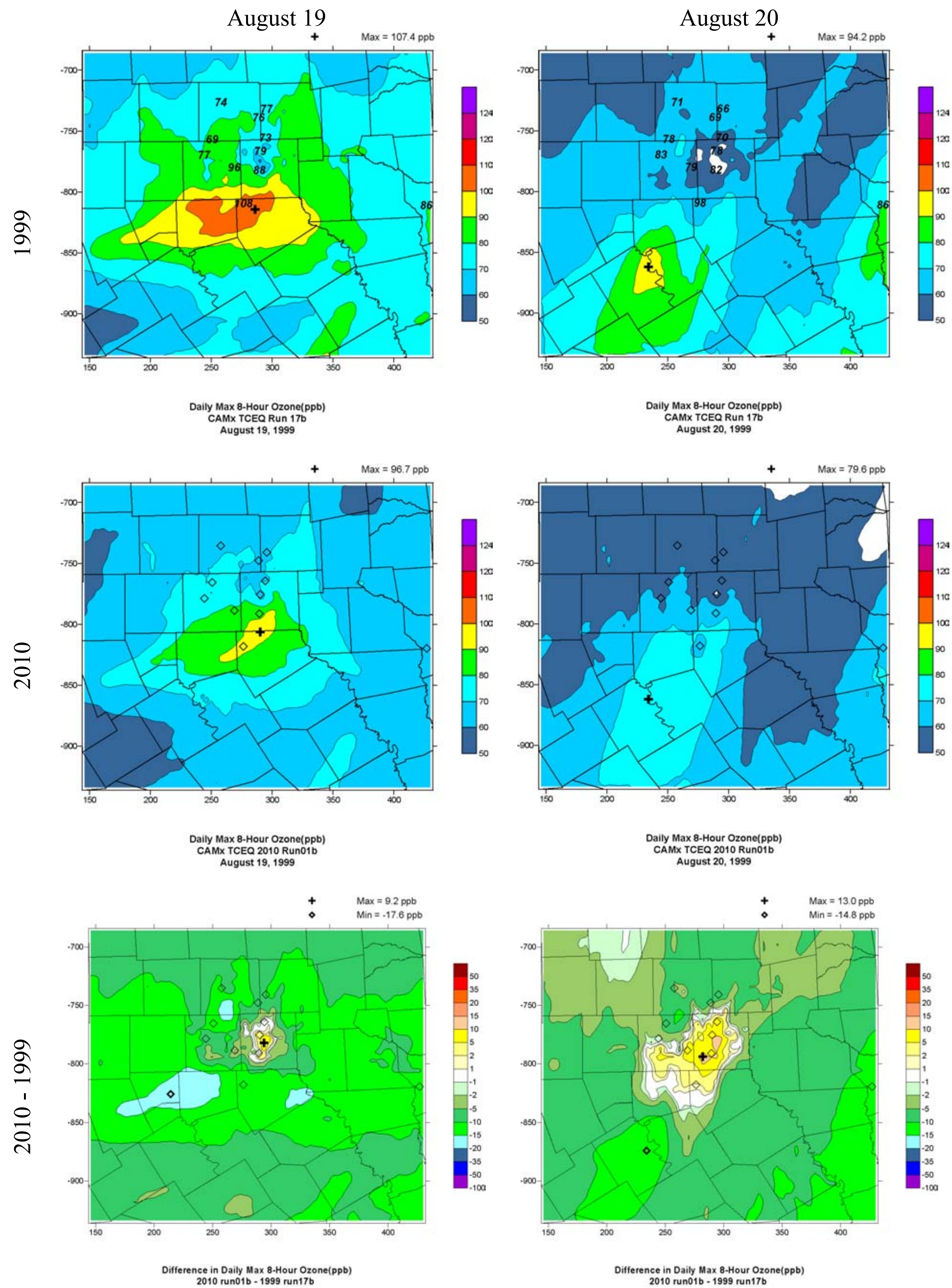


Figure 3-3. Daily maximum 8-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

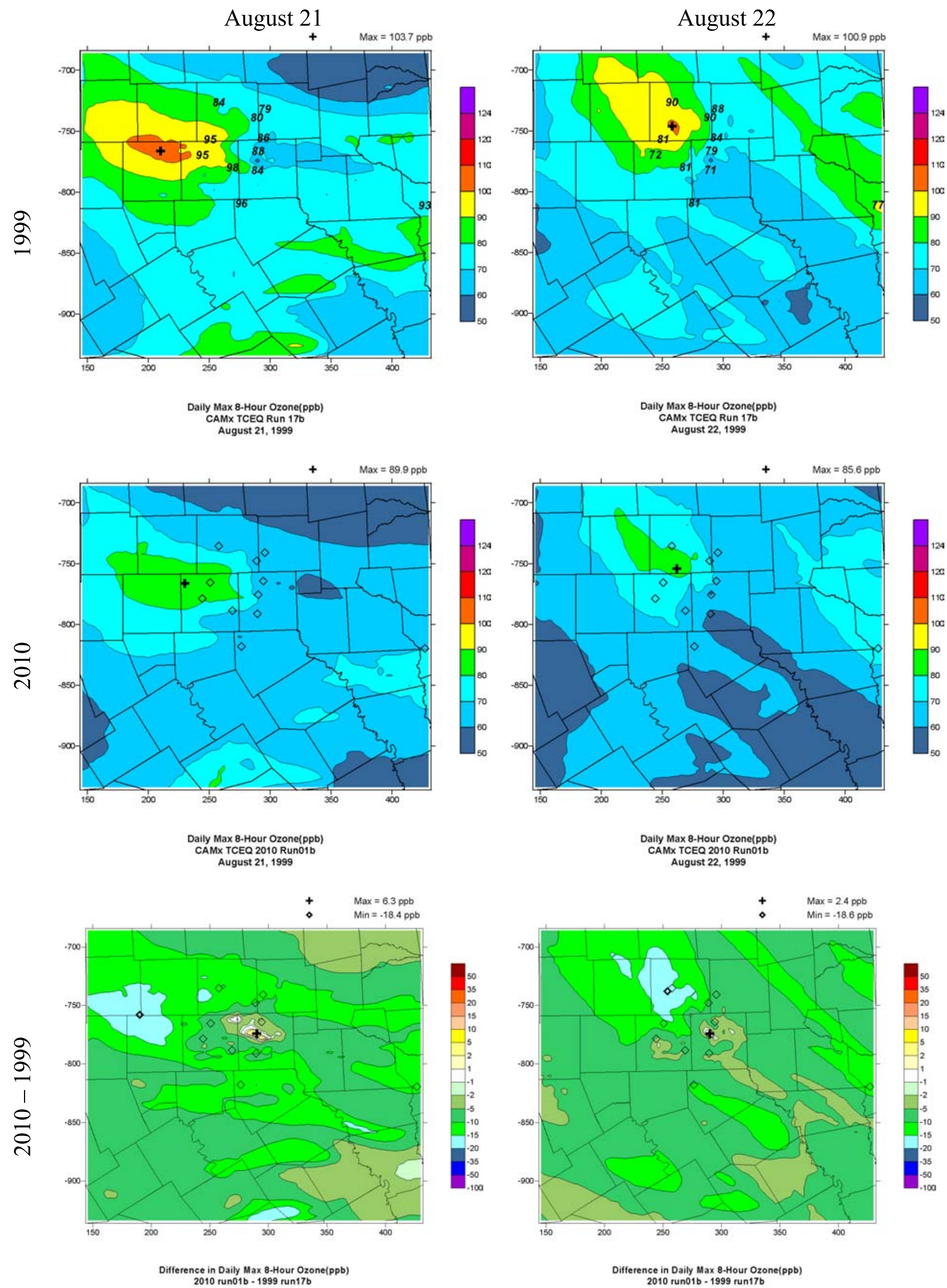


Figure 3-3. Daily maximum 8-hour ozone (ppb) in the 4-km domain in 2010 and 1999 and difference (2010-1999).

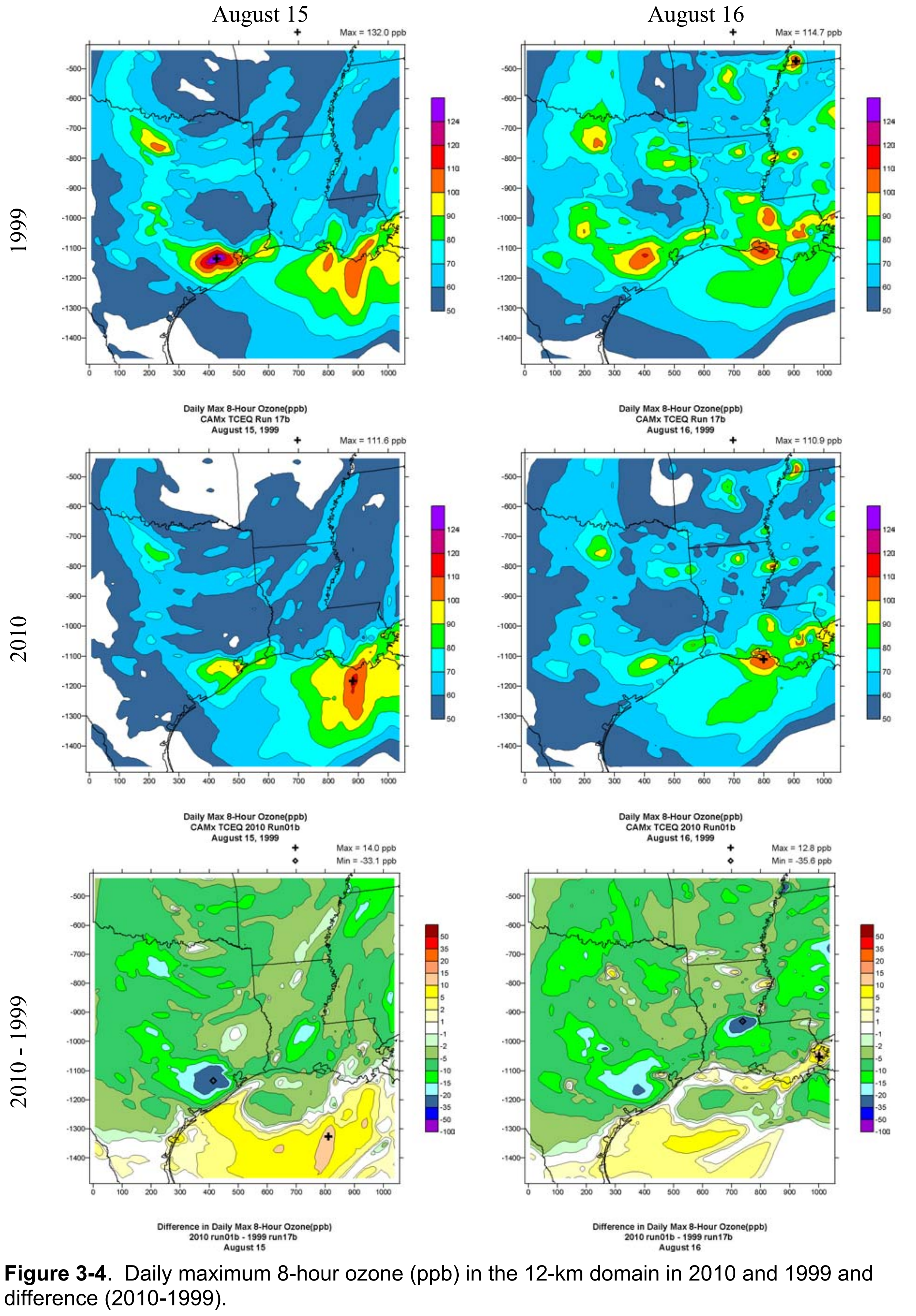


Figure 3-4. Daily maximum 8-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

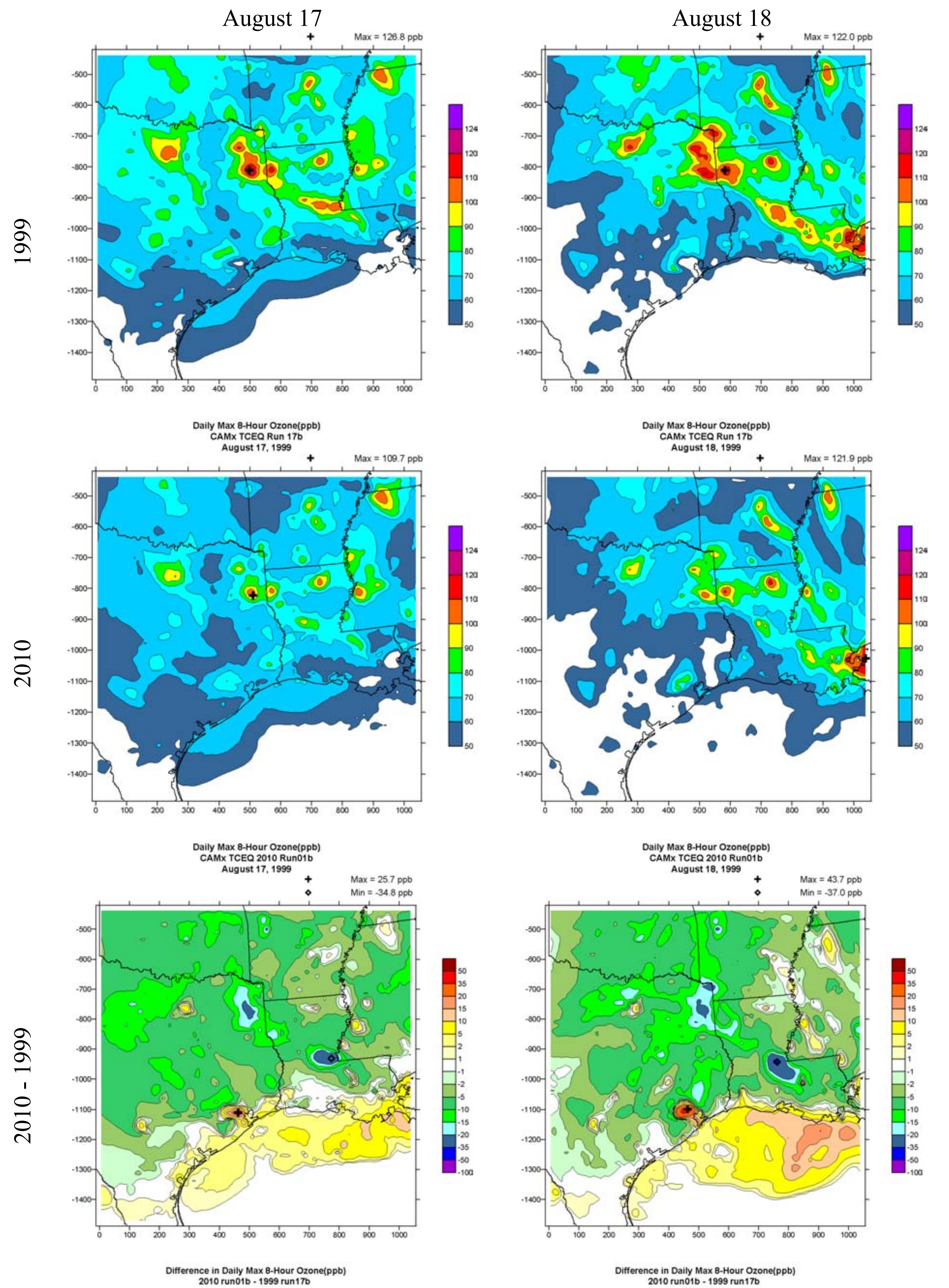


Figure 3-4. Daily maximum 8-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

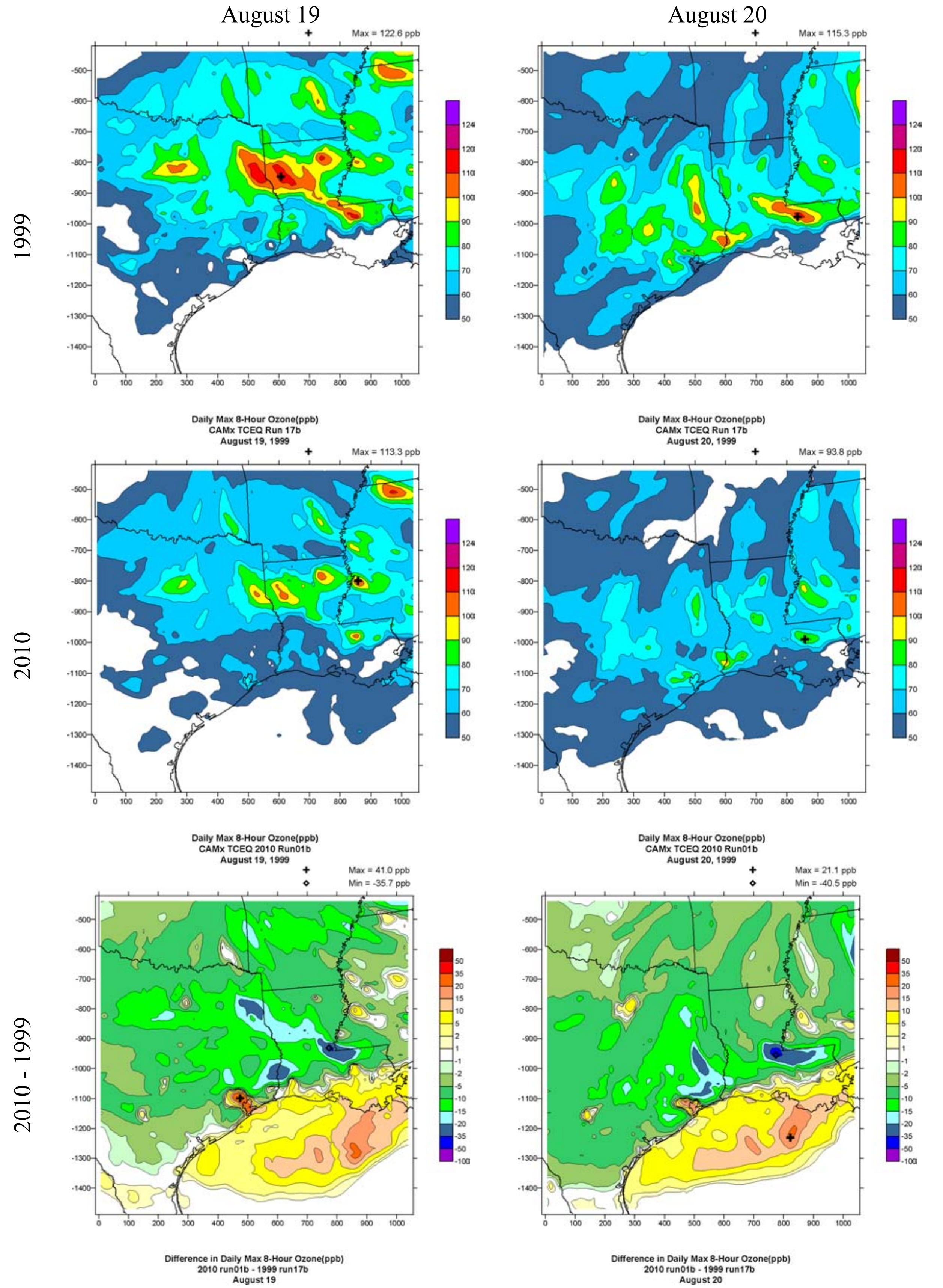


Figure 3-4. Daily maximum 8-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

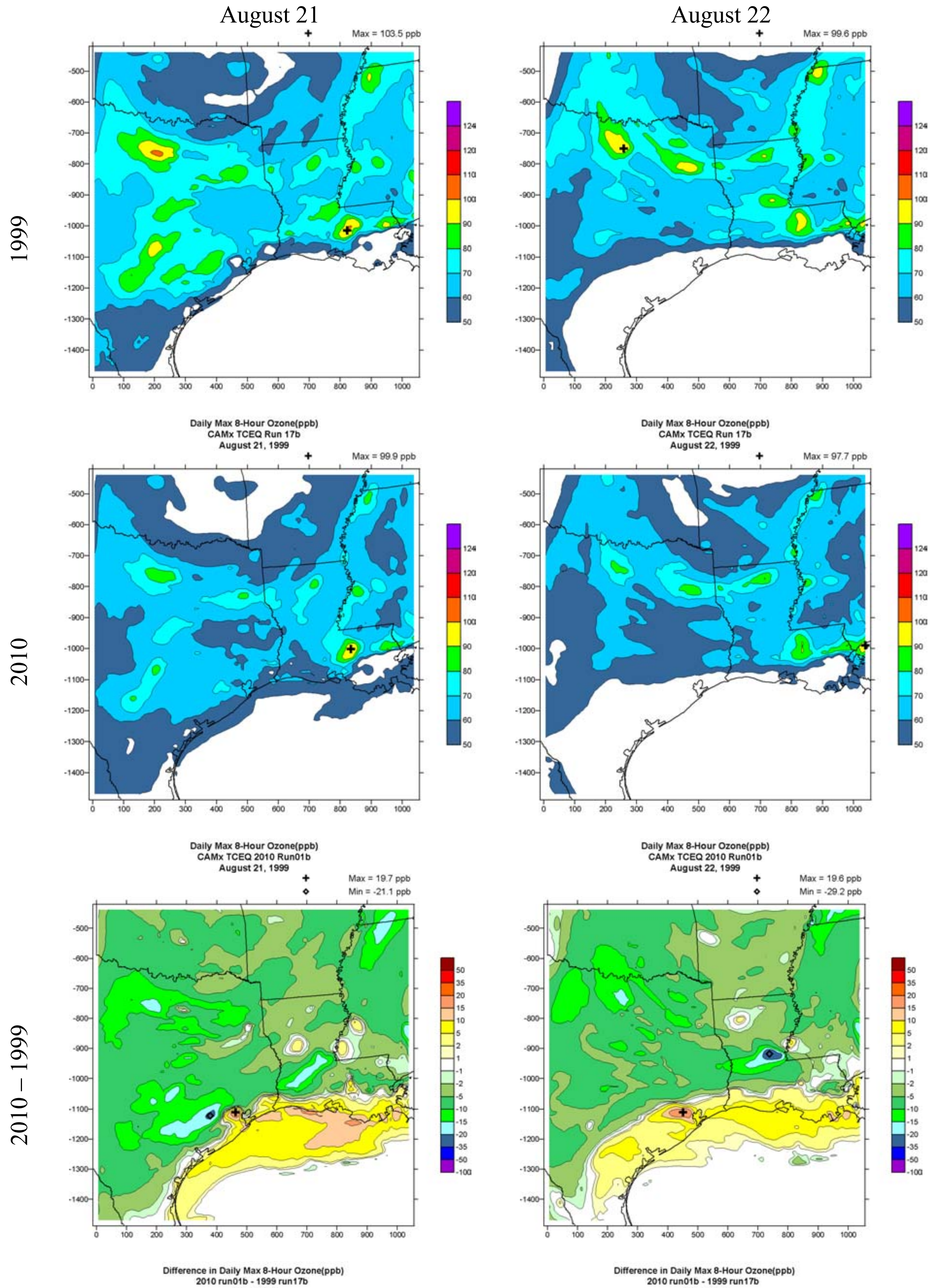


Figure 3-4. Daily maximum 8-hour ozone (ppb) in the 12-km domain in 2010 and 1999 and difference (2010-1999).

PROJECTED 2010 8-HOUR OZONE DESIGN VALUES

Design Value Scaling Methodology for 8-Hour Ozone

The methodology for the 8-hour ozone attainment test was described in draft modeling guidance issued by EPA (EPA, 1999). The methodology calls for scaling base year design values (DVs) by relative reduction factors (RRFs) derived from a photochemical model in order to estimate future design values using the following equations:

Future Year DV = Base Year DV × Relative Reduction Factor

RRF = Future Year Modeled Ozone / Base Year Modeled Ozone

This methodology is conceptually simple, but the implementation is complicated and is described in detail below. This methodology was implemented in a computer program to automate the calculation for efficiency and reliability.

Calculating RRFs

RRFs are calculated for each monitor location. In addition, since high ozone can also occur away from monitor locations, a screening calculation is also carried out to identify grid cells with consistently high ozone. If any screening cells are identified, RRFs are then calculated for the screened grid cells. The idea behind the screening cells is to account for any areas with consistently high modeled ozone that are not captured by the monitoring network. Since there is no base year DV for a screening cell, the DV from a nearby representative monitor must be used. The attainment test is passed when all the future year scaled DVs are 84 ppb or less.

Figure 3-5 shows a schematic outline of the calculations and identifies the input data required to complete the calculation. These are:

1. A monitor list – the list of monitors along with base year DVs for each monitor.
2. A screening cell list – the list of cells to be considered in the screening cell calculation along with the monitors that are considered to be associated with that grid cell. This list may be a sub-set of the modeling grid covering just the area for which controls are being developed. The significance of associating monitors with each grid cell is in the selection of an appropriate base year DV for the grid cell and in setting concentration thresholds for including the grid cell in the screening calculation, discussed below. There are no firm criteria for deciding how to associate monitors with grid cells.
3. Base case ozone – gridded 8-hour daily maximum ozone for the base year.
4. Future case ozone – gridded 8-hour daily maximum ozone for the future year.

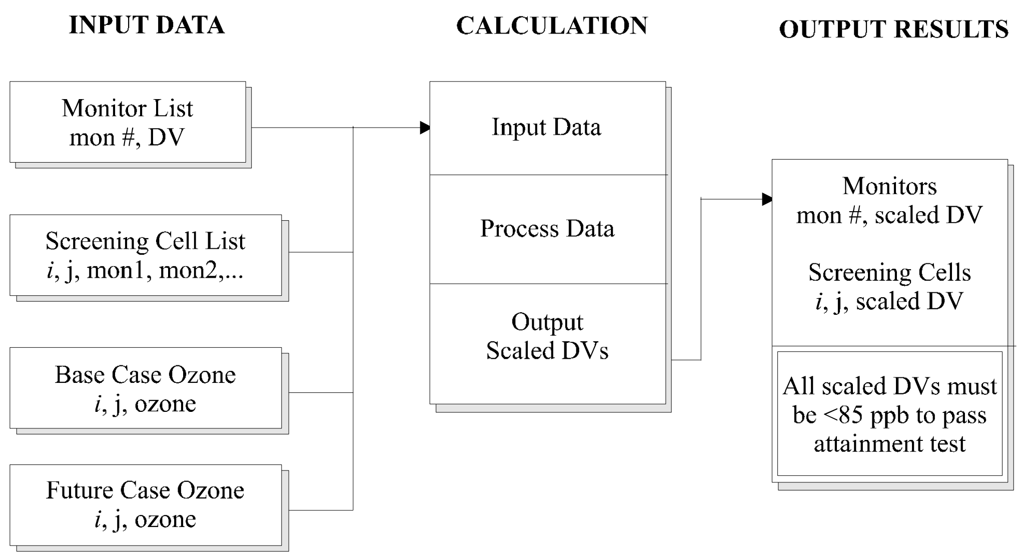


Figure 3-5. Overview of the 8-hour ozone attainment test methodology.

The details of the calculations are as follows:

- Monitor-specific DV Scaling

1. For each monitor, find the daily maximum 8-hour ozone in an *n* x *n* block of cells around the monitor for both the base and future case. Repeat for each modeling day being used for control strategy development. For a 4 km grid, *n*=7 or 9 are consistent with the guidance.
2. Exclude days when the modeled base case daily maximum 8-hour ozone was below 70 ppb.
3. Average the daily maximum 8-hour ozone across days for the base and future year.
4. Calculate the RRF = (average future daily max) / (average base daily max).
5. Calculate the scaled DV = base year DV x RRF and truncate the result to the nearest ppb.
6. Repeat 1-5 for each monitor

- Screening Cell DV Scaling

7. For each grid cell on the screening cell list, count the number of days where the modeled daily maximum 8-hour ozone is at least 5% greater than the modeled daily maximum 8-hour ozone at any "associated" monitor, and at least 70 ppb.
8. If the number of days is 50% or greater of the total days, treat this cell as if it were a monitor – this is a "screened cell."
9. The base year DV to be used for a screened cell is the maximum of the base year DVs for any "associated" monitor.
10. Calculated the scaled DV for each screened cell as if it were a monitor (steps 1-5 above).
11. Repeat 7-10 for each grid cell on the screening cell list.

We make two deviations from EPA's draft guidance (EPA, 1999). First, in Step 4 the draft guidance says to round the average base and future daily maximum 8-hour ozone concentrations to the nearest ppb before calculating the RRFs, whereas we use the full precision of the modeled values. Rounding the average daily maximum 8-hour ozone concentrations in Step 4 doesn't make sense at this point in the calculations as it looses precision and will result in "stepfunction" RRFs that are illogical. The second deviation from EPA's draft guidance is that they recommend rounding the RRFs to 2 digits to the right of the decimal point, whereas again we use full precision. Again we believe this is an unnecessary loss of precision, however in this case it has little effect.

Dallas/Ft. Worth 8-Hour Design Values

The current 8-hour design values for the Dallas/Ft. Worth non-attainment area are presented in Table 3-3. The 8-hour design value for an individual monitor is defined as the fourth highest monitored 8-hour ozone value averaged over the most recent three years of data. EPA will use the 2000-2003 design values for 8-hour ozone attainment designations. However, because the modeling episode is for 1999, the EPA modeling guidance (EPA, 1999) says that the design value scaling must consider the higher of the design values corresponding to the base year (1998-2000) and the attainment designation (2001 to 2003) at each monitor.

Table 3-3 shows the base year (1998-2000) and attainment designation (2001-2003) design values for monitors in the DFW area. Also presented in Table 3-3 is the maximum design value over these two periods. Figure 3-6 displays the location of ozone monitors within the DFW nonattainment area. The specific period for which the maximum design value occurs is also denoted in Figure 3-6.

Table 3-3. DFW 8-Hour O3 Design Values.

County	City	CAMS	1998-2000	2001-2003	Max DV	Ending Year of Max DV
Collin	Frisco	C31	101	88	101	2000
Collin	Anna	C68		80	80	2003
Dallas	Dallas	C60, C401	93	90	93	2000
Dallas	Dallas	C63		86	86	2003
Dallas	Dallas	C402	88	83	88	2000
Dallas	Sunnyvale	C74		83	83	2003
Denton	Denton	C56	102	97	102	2000
Ellis	Midlothian	C94	97	82	97	2000
Hood	Granbury	C73		84	84	2003
Johnson	Cleburne	C77		90	90	2003
Kaufman	Kaufman	C71		73	73	2003
Parker	Weatherford	C76		89	89	2003
Rockwall	Rockwall	C69		81	81	2003
Tarrant	Arlington	C57	95		95	2000
Tarrant	Eagle Mountain Lake	C75		96	96	2003
Tarrant	Fort Worth	C13	99	96	99	2000
Tarrant	Fort Worth	C17	97	100	100	2003
Tarrant	Grapevine	C70		100	100	2003

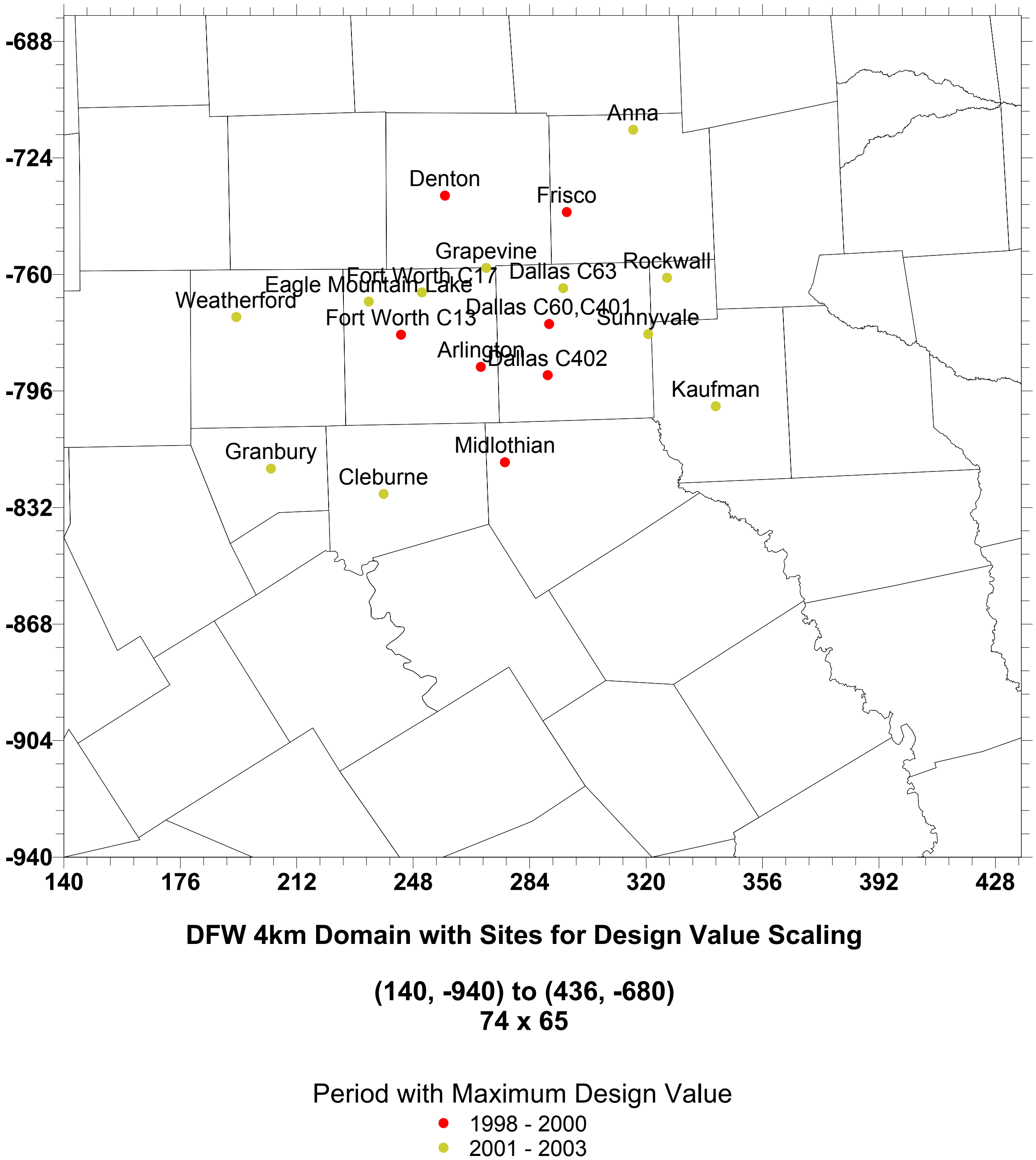


Figure 3-6. DFW ozone monitors and maximum design value periods.

The results of the design value scaling analysis are presented in Table 3-4. Yellow shaded values in the right hand column of the lower panel indicate monitors that fail the attainment test (8-hour O_3 < 85.0) for 2010. Several monitors are seen to fail the attainment test although the scaled 8-hour ozone values at four monitors (Dallas C402, Cleburne, Weatherford and Eagle Mt Lake) have been reduced to below 85 ppb.

Table 3-4. 2010 8-hour ozone design value scaling analysis for monitors in the DFW area. The scaled 2010 design values are in the right hand column of the lower panel.

Base Case: run17b			Base Case Max 8-Hr Ozone (ppb)									#Days above 70 ppb
Site	Max DV	DV year	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	Avg	
Frisco	101	2000	77.5	88.8	88	113.3	82.5	65.7	80.8	89.5	88.6	7
Anna	80	2003	69.6	70	79.2	103.9	86.7	66.2	73.1	82.4	82.6	6
Dallas C60	93	2000	91.2	88.6	89.8	86.3	91.8	63.6	87.2	84.1	88.4	7
Dallas C63	86	2003	86.4	83.7	84.9	91.7	86.7	62.7	82	87.3	86.1	7
Dallas C402	88	2000	91.2	88.6	89.8	80.9	102.8	70.9	87.2	77.2	86.1	8
Sunnyvale	83	2003	67.4	69	77.2	82.9	87	65.1	72.6	73.2	78.6	5
Denton	102	2000	94.6	103	107.2	116.5	86.3	67	92.9	100.9	100.2	7
Midlothian	97	2000	72.3	73.1	83.2	74.5	107.4	75.4	76.3	73.6	79.5	8
Granbury	84	2003	85.7	72.7	79.4	72	98.8	72.7	82.8	74.3	79.8	8
Cleburne	90	2003	80.2	75.8	80.9	67.6	102.7	86.2	81.7	74.1	83.1	7
Kaufman	73	2003	69.2	65.8	74.4	74.8	91.2	66.4	76.1	70.6	77.4	5
Weatherford	89	2003	100.4	89.9	98.5	73.4	81.7	65.6	103	80.5	89.6	7
Rockwall	81	2003	69	68.6	77.2	84.6	87	64.3	76.2	74	79.8	5
Arlington	95	2000	97.8	90.6	96.2	82.2	100.7	67.6	92.9	82.2	91.8	7
Eagle Mt Lake	96	2003	107.2	102.8	106.7	96.1	86	65.8	101.6	93.4	99.1	7
Fort Worth C13	99	2000	106.4	100.5	106.2	92.5	89.6	71.2	100.6	91.1	94.8	8
Fort Worth C17	100	2003	104.3	102.7	108	102	88.9	71.2	97.8	99.9	96.9	8
Grapevine	100	2003	101.7	103	107	113.4	88.9	71.2	94.6	100.9	97.6	8

Future Year: 10run01b			Future Case Max 8-Hr Ozone (ppb)										2010 Scaled DV
Site	Max DV	DV year	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	Avg	RRF	
Frisco	101	2000	66.9	88.6	86.5	106.3	72.0	58.8	71.2	76.2	81.1	0.915	92.4
Anna	80	2003	60.1	62.1	71.6	91.1	75.1	60.6	62.9	69.4	72.0	0.873	69.8
Dallas C60	93	2000	77.9	88.1	90.3	85.3	89.3	67.3	80.1	77.1	84.0	0.950	88.3
Dallas C63	86	2003	74.6	86.5	85.4	94.8	81.7	63.5	77.7	76.0	82.4	0.957	82.3
Dallas C402	88	2000	76.4	84.5	86.8	80.0	96.1	72.2	80.1	67.7	80.5	0.935	82.3
Sunnyvale	83	2003	60.3	65.3	71.9	77.8	82.5	61.2	67.0	66.2	73.1	0.930	77.2
Denton	102	2000	78.4	93.0	97.6	103.9	70.8	59.0	77.7	83.5	86.4	0.862	88.0
Midlothian	97	2000	66.0	68.8	77.0	67.0	96.7	75.5	66.3	66.2	72.9	0.918	89.0
Granbury	84	2003	75.6	66.1	69.9	65.9	81.4	65.7	76.2	65.2	70.8	0.887	74.5
Cleburne	90	2003	72.1	68.9	71.7	59.8	87.4	79.2	72.5	64.2	73.7	0.887	79.9
Kaufman	73	2003	57.9	59.8	69.2	65.2	79.6	58.9	65.9	63.6	68.7	0.887	64.7
Weatherford	89	2003	83.3	78.1	84.0	60.6	69.0	59.4	85.5	69.1	75.6	0.844	75.1
Rockwall	81	2003	59.2	64.5	71.9	78.2	75.8	58.7	64.3	66.2	71.3	0.894	72.4
Arlington	95	2000	79.9	85.4	88.8	80.0	92.7	70.7	82.0	73.6	83.2	0.906	86.1
Eagle Mt Lake	96	2003	89.0	92.1	97.0	82.1	74.6	62.0	89.9	79.1	86.2	0.870	83.5
Fort Worth C13	99	2000	87.0	94.7	99.0	84.2	81.7	66.7	88.6	78.9	85.1	0.898	88.9
Fort Worth C17	100	2003	85.0	97.1	103.7	89.6	76.1	62.9	88.6	85.6	86.1	0.889	88.9
Grapevine	100	2003	84.8	97.1	103.7	108.7	73.4	61.8	87.9	85.6	87.9	0.900	90.0

Note: Yellow shaded values are 85 ppb or higher.

EMISSION SENSITIVITY SIMULATIONS FOR 2010

Several 2010 emission reductions scenarios were performed to provide "directional guidance" on emission reductions necessary to bring the DFW area into attainment of the 8-hour ozone standard and thereby support the DFW SIP development. Specifically, anthropogenic NOx and VOC reductions were applied, both separately and in combination, to emissions within the 9-county DFW area. These sensitivities can be used to estimate the level of emission reductions required for an 8-hour ozone attainment demonstration. The sensitivities also address whether NOx and/or VOC emission controls are more effective in reducing ozone, and whether the relative effectiveness of VOC vs. NOx reduction changes with the magnitude of emissions reductions. Table 3-5 summarizes the emission reduction scenarios that were performed.

Table 3-5. Emission reduction matrix for 'Directional Guidance' sensitivity simulations.

Anthropogenic Reduction		NOx			
		0%	20%	40%	60%
VOC	0%	Future Base	X	X	X
	25%	X	X	-	-
	50%	X		X	-
	75%	X	-	-	X

In addition to across-the-board anthropogenic emission reductions, a number of category specific emission reductions were performed to determine whether reductions in one source category are more effective than another. A nominal value of 40 tons per day (tpd) was selected for these sensitivities. The 40 tpd sensitivities were evaluated for the following five emissions categories:

- On-road mobile source NOx
- On-road mobile source VOC
- Off-road mobile plus area source NOx
- Off-road mobile plus area source VOC
- Point source NOx

The 40 tpd sensitivity test was not performed for point source VOC because this category did not contain 40 tpd of emissions (Table 3-6). As the emissions inventory varies from day to day, the percentage reduction corresponding to a 40 tpd reduction across the 9-county DFW region also varies from day to day. The daily emissions for each of the nine DFW counties and the corresponding percentage required to achieve a 40 tpd reduction in emissions are presented in Table 3-6.

Table 3-6. Emission category specific percentage reductions needed for a 40 tpd reduction across the DFW 9-County region.

	On-Road Mobile		All Points		Area + Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
Aug 13 (Friday)						
County						
Collin	11.7	7.7	3.0	1.2	14.9	19.0
Dallas	62.3	38.3	18.0	12.2	67.8	111.7
Denton	13.9	8.2	2.7	1.7	17.9	23.2
Tarrant	41.6	25.1	13.0	9.7	54.4	85.8
Parker	5.7	2.4	4.1	1.0	5.1	13.0
Johnson	5.3	2.9	4.4	0.2	7.7	15.5
Ellis	8.2	2.7	44.5	6.9	9.0	15.0
Kaufman	5.8	2.8	6.8	2.0	3.2	14.1
Rockwall	2.3	0.8	0.0	0.0	1.0	3.7
9 County Total	**156.8**	**90.9**	**96.5**	**34.9**	**181.0**	**300.9**
% Reduction	**26%**	**44%**	**41%**	**N/A**	**22%**	**13%**
Aug 14 (Saturday)						
County						
Collin	8.0	5.4	2.2	0.6	10.7	16.4
Dallas	40.7	26.9	17.4	9.3	50.6	79.0
Denton	9.3	5.8	2.6	1.1	15.8	21.3
Tarrant	28.4	17.8	12.3	7.1	43.8	55.0
Parker	3.8	2.0	4.2	1.0	4.8	11.6
Johnson	3.6	2.4	4.3	0.2	7.2	11.5
Ellis	5.1	2.3	44.5	6.8	6.6	13.2
Kaufman	3.8	2.4	6.8	2.0	2.8	7.9
Rockwall	1.3	0.6	0.0	0.0	0.7	3.3
9 County Total	**104.0**	**65.7**	**94.3**	**28.1**	**142.9**	**219.2**
% Reduction	**38%**	**61%**	**42%**	**N/A**	**28%**	**18%**
Aug 15 (Sunday)						
County						
Collin	6.1	4.3	2.7	0.6	8.3	13.0
Dallas	31.2	21.4	16.9	9.3	38.0	62.2
Denton	6.9	4.6	2.5	1.1	14.4	18.6
Tarrant	20.7	14.1	12.9	7.2	36.1	43.8
Parker	3.4	2.0	4.3	1.0	4.6	9.5
Johnson	3.5	2.4	4.3	0.2	6.8	8.6
Ellis	4.8	2.4	44.5	6.8	5.4	10.2
Kaufman	3.8	2.4	6.8	2.0	2.6	5.6
Rockwall	1.0	0.5	0.0	0.0	0.5	2.6
9 County Total	**81.3**	**54.2**	**95.0**	**28.2**	**116.7**	**174.1**
% Reduction	**49%**	**74%**	**42%**	**N/A**	**34%**	**23%**
Aug 16 (Monday)						
County						
Collin	11.9	7.0	3.0	1.2	14.9	19.0
Dallas	62.9	34.3	18.0	12.2	67.8	111.7
Denton	14.1	7.5	2.7	1.7	17.9	23.2
Tarrant	42.0	22.8	13.0	9.7	54.4	85.8

	On-Road Mobile		All Points		Area + Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
Parker	4.9	1.8	4.1	1.0	5.1	13.0
Johnson	4.5	2.2	4.4	0.2	7.7	15.5
Ellis	6.8	2.1	44.5	6.9	9.0	15.0
Kaufman	5.0	2.1	6.8	2.0	3.2	14.1
Rockwall	2.3	0.7	0.0	0.0	1.0	3.7
9 County Total	**154.5**	**80.4**	**96.5**	**34.9**	**181.0**	**300.9**
% Reduction	**26%**	**50%**	**41%**	**N/A**	**22%**	**13%**
Aug 17 (Tuesday)						
County						
Collin	11.9	7.2	3.0	1.2	14.9	19.0
Dallas	62.4	35.2	18.0	12.2	67.8	111.7
Denton	14.3	7.7	2.7	1.7	17.9	23.2
Tarrant	42.2	23.2	13.0	9.7	54.4	85.8
Parker	5.0	1.9	4.1	1.0	5.1	13.0
Johnson	4.4	2.2	4.4	0.2	7.7	15.5
Ellis	6.8	2.1	44.5	6.9	9.0	15.0
Kaufman	4.9	2.1	6.8	2.0	3.2	14.1
Rockwall	2.3	0.8	0.0	0.0	1.0	3.7
9 County Total	**154.4**	**82.3**	**96.5**	**34.9**	**181.0**	**300.9**
% Reduction	**26%**	**49%**	**41%**	**N/A**	**22%**	**13%**
Aug 18 (Wednesday)						
County						
Collin	11.4	7.2	3.0	1.2	14.9	19.0
Dallas	60.2	35.4	18.0	12.2	67.8	111.7
Denton	13.6	7.7	2.7	1.7	17.9	23.2
Tarrant	40.0	23.3	13.0	9.7	54.4	85.8
Parker	4.8	1.9	4.1	1.0	5.1	13.0
Johnson	4.2	2.2	4.4	0.2	7.7	15.5
Ellis	6.7	2.1	44.5	6.9	9.0	15.0
Kaufman	4.7	2.1	6.8	2.0	3.2	14.1
Rockwall	2.2	0.8	0.0	0.0	1.0	3.7
9 County Total	**147.8**	**82.7**	**96.5**	**34.9**	**181.0**	**300.9**
% Reduction	**27%**	**48%**	**41%**	**N/A**	**22%**	**13%**
Aug 19 (Thursday)						
County						
Collin	11.8	7.3	3.0	1.2	14.9	19.0
Dallas	60.9	35.6	18.0	12.2	67.8	111.7
Denton	13.6	7.8	2.7	1.7	17.9	23.2
Tarrant	40.0	23.4	13.0	9.7	54.4	85.8
Parker	4.7	1.9	4.1	1.0	5.1	13.0
Johnson	4.2	2.3	4.4	0.2	7.7	15.5
Ellis	6.7	2.1	44.5	6.9	9.0	15.0
Kaufman	4.7	2.1	6.8	2.0	3.2	14.1
Rockwall	2.2	0.8	0.0	0.0	1.0	3.7
9 County Total	**148.9**	**83.2**	**96.5**	**34.9**	**181.0**	**300.9**
% Reduction	**27%**	**48%**	**41%**	**N/A**	**22%**	**13%**

	On-Road Mobile		All Points		Area + Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
Aug 20 (Friday)						
County						
Collin	13.6	7.8	3.0	1.2	14.9	19.0
Dallas	69.1	38.0	18.0	12.2	67.8	111.7
Denton	16.0	8.3	2.7	1.7	17.9	23.2
Tarrant	47.8	25.2	13.0	9.7	54.4	85.8
Parker	6.7	2.4	4.1	1.0	5.1	13.0
Johnson	6.1	2.8	4.4	0.2	7.7	15.5
Ellis	8.8	2.7	44.5	6.9	9.0	15.0
Kaufman	6.6	2.7	6.8	2.0	3.2	14.1
Rockwall	2.6	0.8	0.0	0.0	1.0	3.7
9 County Total	**177.2**	**90.8**	**96.5**	**34.9**	**181.0**	**300.9**
% Reduction	**23%**	**44%**	**41%**	**N/A**	**22%**	**13%**
Aug 21 (Saturday)						
County						
Collin	8.2	5.4	2.2	0.6	10.7	16.4
Dallas	42.3	26.3	17.4	9.3	50.6	79.0
Denton	9.4	5.8	2.6	1.1	15.8	21.3
Tarrant	28.3	17.4	12.3	7.1	43.8	55.0
Parker	3.9	2.0	4.2	1.0	4.8	11.6
Johnson	3.8	2.4	4.3	0.2	7.2	11.5
Ellis	5.2	2.3	44.5	6.8	6.6	13.2
Kaufman	4.0	2.3	6.8	2.0	2.8	7.9
Rockwall	1.3	0.6	0.0	0.0	0.7	3.3
9 County Total	**106.5**	**64.4**	**94.3**	**28.1**	**142.9**	**219.2**
% Reduction	**38%**	**62%**	**42%**	**N/A**	**28%**	**18%**
Aug 22 (Sunday)						
County						
Collin	5.8	4.4	2.7	0.6	8.3	13.0
Dallas	31.1	21.5	16.9	9.3	38.0	62.2
Denton	6.8	4.7	2.5	1.1	14.4	18.6
Tarrant	20.5	14.2	12.9	7.2	36.1	43.8
Parker	3.4	2.0	4.3	1.0	4.6	9.5
Johnson	3.5	2.4	4.3	0.2	6.8	8.6
Ellis	4.7	2.4	44.5	6.8	5.4	10.2
Kaufman	3.6	2.4	6.8	2.0	2.6	5.6
Rockwall	0.9	0.5	0.0	0.0	0.5	2.6
9 County Total	**80.3**	**54.4**	**95.0**	**28.2**	**116.7**	**174.1**
% Reduction	**50%**	**73%**	**42%**	**N/A**	**34%**	**23%**

Note: The percentage reduction for point source VOC is not applicable (N/A) because this sensitivity was not evaluated.

The percentage reductions calculated in Table 3-6 were applied uniformly across the 9 county DFW region. In this way, the analysis does not favor any particular county over the others in the region. Examination of Table 3-6 shows emission reductions ranging from approximately 13% to 75%, depending on the episode day, pollutant and emission source category.

Each of the emission reduction scenarios described above was simulated in CAMx. For each simulation, the 2010 8-hour ozone design values for each DFW monitor were calculated using the EPA design value (DV) scaling methodology described above (e.g., Table 3-2). The scaled 2010 DVs are presented in Table 3-7 for the "across the board" percentage reduction sensitivity tests (defined in Table 3-5). The scaled 2010 DVs for the "40 tpd reduction" sensitivity tests are presented in Table 3-8. To allow more accurate evaluation of the effect of each sensitivity test, the scaled design values shown in Tables 3-7 and 3-8 are not truncated to the nearest ppb.

The results of the "across the board" percentage reductions sensitivity tests are presented graphically in Figures 3-7 through 3-9. Note the monitor values illustrated in the figures are scaled DVs calculated according to EPA's methodology. In order to demonstrate attainment, all these scaled DVs must be below 85 ppb, although weight of evidence arguments can be used for future year DVs below 90 ppb.

Results for "Across the Board" Emission Reductions

The following findings are based on the results of the "across the board" emission reduction sensitivity tests presented in Table 3-7 and Figures 3-7 through 3-9:

- NOx controls are more effective than VOC controls in reducing 8-hour ozone at all monitors in the DFW area.
- VOC controls within the 9-County area do help to reduce 8-hour ozone concentrations in the DFW area. It is likely that the benefits of VOC controls result from VOC reductions in parts of the 9-County area that have the highest NOx emission levels.
- About 50% "across the board" NOx reduction in the 9-County area is needed to bring the highest ozone monitor into 8-hour ozone attainment (i.e., below 85 ppb).
- The four monitors that are hardest to bring into 8-hour ozone attainment with "across the board" NOx reductions are Frisco, Midlothian, Dallas CAMS63 and Grapevine.
- There are no "NOx disbenefits" in the responses of 8-hour ozone design values to NOx control, i.e., there are no increases in 8-hour ozone design values resulting from NOx controls.
- The Frisco monitor is the hardest to bring into 8-hour ozone attainment using "across the board" NOx reductions. Frisco is responsive to NOx reductions in the 9-County area but is the hardest monitor to control because it has the highest design value in the 2010 base case.
- Several monitors (i.e., CAMS63 and CAMS60) respond poorly to NOx reductions at about the 20% level. These monitors respond well to deeper NOx reductions. One consequence is that these monitors are among the hardest to bring into attainment even though they do not have the highest design values in the 2010 base case. This poor initial response to NOx reduction is likely due to the proximity of these monitors to areas of "NOx disbenefit" seen between 1999 and 2010 in Figure 3-3.

- The Midlothian monitor shows less response to across the board NOx emission reductions in the 9-County area than other monitors. Consequently, the Midlothian monitor is among the hardest to bring into 8-hour ozone attainment even though it does not have the highest design values in the 2010 base case. This poor response is likely because the Midlothian monitor was upwind of the majority of the emission reductions on most of the episode days. The standard EPA design value scaling approach may not work well for the Midlothian monitor.

Results for "40 Ton Per Day" Emission Reductions

The results of the "40 ton per day" emission reductions are shown graphically in Figure 3-10 for the four hardest to control monitors (Frisco, CAMS-63, Midlothian and Grapevine). Results for all monitor locations are presented in Table 3-8. The relative effectiveness of controlling different categories of emissions may be judged based on the ppb reduction in 8-hour ozone DV per ton of emissions reduced shown in Figure 3-10. The main findings from Figure 3-10 are:

- NOx reductions are more effective than VOC reductions at lowering ozone at all four "hardest to control" monitors.
- NOx reductions from point sources are less effective at lowering ozone than NOx reductions from on-road, off-road or area sources at the Frisco and Grapevine monitor locations.
- NOx reductions from all sources are about equally effective at lowering ozone at the Dallas CAMS60 and Midlothian monitor locations.

These results show that there are differences between monitors and suggest that the control strategy design can be made more effective by accounting for the specific sources that influence ozone at each monitor.

Table 3-7. 2010 8-hour ozone design values (ppb) at DFW monitors for sensitivity tests with "across the board" anthropogenic emission reductions in the DFW 9-County area.

Run Name	10run01b	N20V00	N40V00	N60V00	N00V25	N00V50	N00V75	N20V25	N40V50	N60V75
NOx Reduction	0%	20%	40%	60%	0%	0%	0%	20%	40%	60%
VOC Reduction	0%	0%	0%	0%	25%	50%	75%	25%	50%	75%
Monitor										
Frisco	92.4	90.7	87.7	83.1	91.5	90.4	89.3	89.9	86.6	82.2
Anna	69.8	68.8	67.7	66.3	69.6	69.3	69.0	68.6	67.4	66.0
Dallas C60	88.3	87.2	85.1	80.8	87.4	86.3	85.4	86.3	83.5	79.3
Dallas C63	82.3	81.4	79.5	75.8	81.3	80.3	79.4	80.6	78.1	74.4
Dallas C402	82.3	80.4	77.7	73.6	81.7	81.2	80.5	79.9	77.0	73.0
Sunnyvale	77.2	76.1	74.8	72.7	76.9	76.6	76.3	75.7	74.2	72.1
Denton	88.0	84.6	80.3	74.7	87.4	86.8	86.1	84.2	79.7	74.4
Midlothian	89.0	87.6	85.7	82.9	88.5	88.0	87.5	87.3	85.1	82.4
Granbury	74.5	73.2	71.8	70.3	74.4	74.3	74.3	73.1	71.8	70.3
Cleburne	79.9	78.0	75.8	73.2	79.6	79.4	79.1	77.8	75.6	73.1
Kaufman	64.7	64.1	63.4	62.5	64.7	64.5	64.4	64.0	63.3	62.4
Weatherford	75.1	72.6	69.8	66.4	75.0	74.8	74.6	72.6	69.7	66.4
Rockwall	72.4	71.4	70.1	68.5	72.2	72.0	71.9	71.2	69.9	68.4
Arlington	86.1	83.4	79.8	75.0	85.7	85.3	84.9	83.1	79.4	74.7
Eagle Mt Lake	83.5	80.3	76.3	71.2	83.1	82.6	82.0	80.0	75.9	70.9
Fort Worth C13	88.9	86.1	82.1	76.7	88.3	87.7	87.1	85.6	81.5	76.3
Fort Worth C17	88.9	86.0	82.0	76.4	88.2	87.5	86.8	85.5	81.4	76.0
Grapevine	90.0	87.4	83.6	78.2	89.2	88.3	87.3	86.7	82.6	77.3

Table 3-8. 2010 8-hour ozone design values (ppb) at DFW monitors for sensitivity tests with 40 tons per day emission reductions in the DFW 9-County area.

Run Name	10run01b	mobile. LessNOx	point. LessNOx	anthro. LessNOx	mobile. LessVOC	anthro. LessVOC
40 ton per day Reduction in:	None	On-Road Mobile	All Points	Area + Off-Road	On-Road Mobile	Area + Off-Road
Monitor						
Frisco	92.4	91.2	91.9	91.5	92.0	92.0
Anna	69.8	69.3	69.5	69.3	69.7	69.7
Dallas C60	88.3	87.6	87.7	87.7	87.9	87.9
Dallas C63	82.3	81.8	81.7	82.0	81.9	81.9
Dallas C402	82.3	81.1	81.3	81.4	82.0	82.1
Sunnyvale	77.2	76.7	76.1	76.9	77.1	77.1
Denton	88.0	85.9	87.0	85.8	87.7	87.7
Midlothian	89.0	88.3	88.2	88.4	88.8	88.8
Granbury	74.5	73.9	73.8	73.9	74.5	74.5
Cleburne	79.9	79.1	78.5	79.1	79.8	79.8
Kaufman	64.7	64.4	64.5	64.5	64.7	64.7
Weatherford	75.1	73.7	73.8	73.8	75.0	75.0
Rockwall	72.4	71.9	71.6	72.0	72.3	72.3
Arlington	86.1	84.5	84.6	84.9	85.9	86.0
Eagle Mt Lake	83.5	81.7	82.3	81.7	83.3	83.3
Fort Worth C13	88.9	87.3	87.7	87.4	88.7	88.7
Fort Worth C17	88.9	87.2	88.0	87.2	88.6	88.6
Grapevine	90.0	88.5	89.2	88.5	89.7	89.7

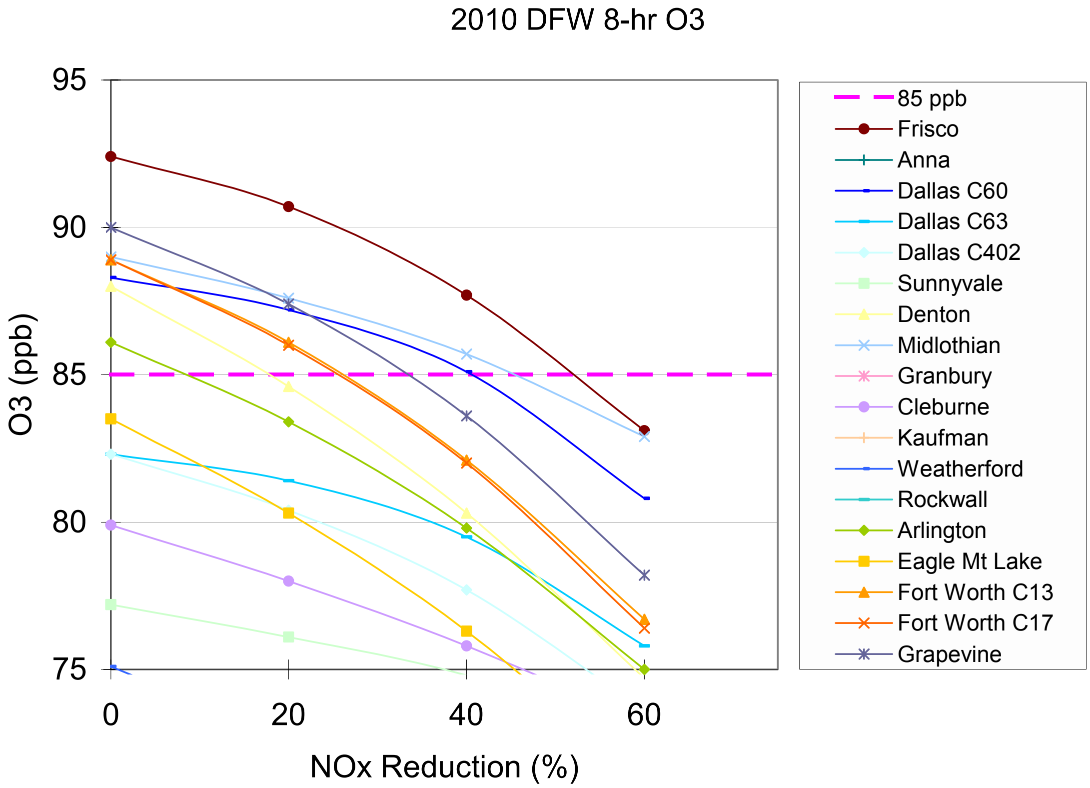


Figure 3-7. Eight-hour ozone response curves for NOx emission reduction scenarios.

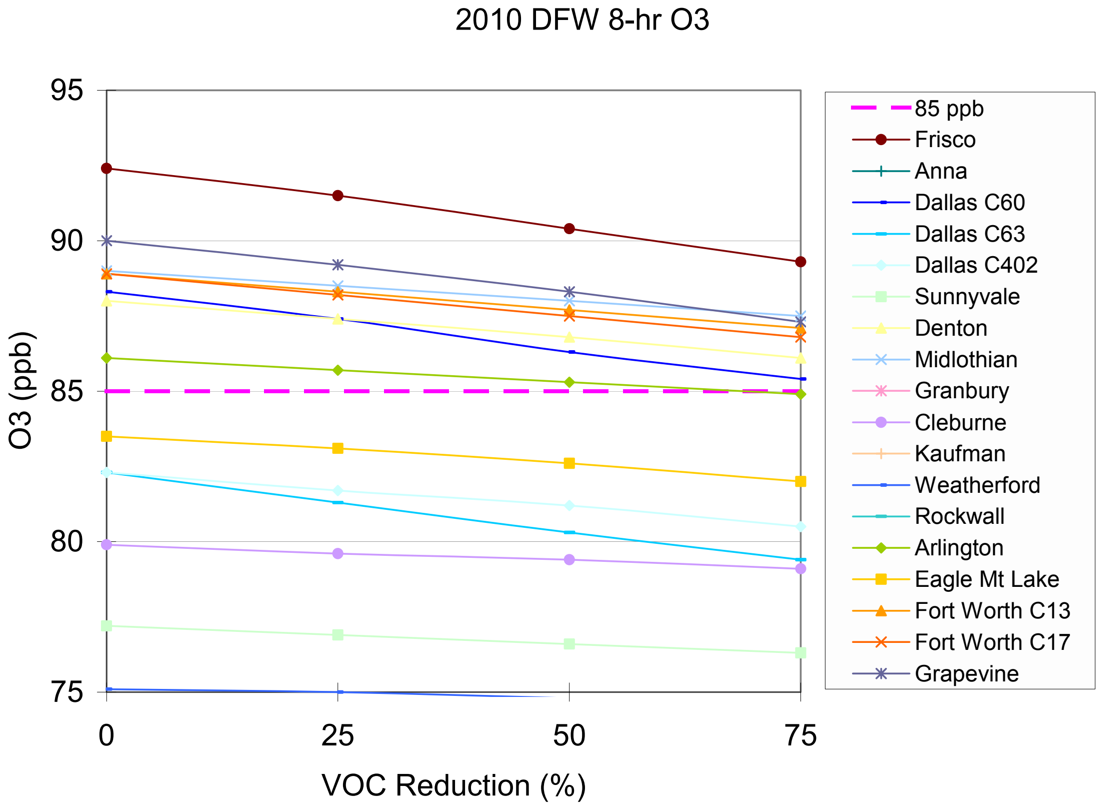


Figure 3-8. Eight-hour ozone response curves for VOC emission reduction scenarios.

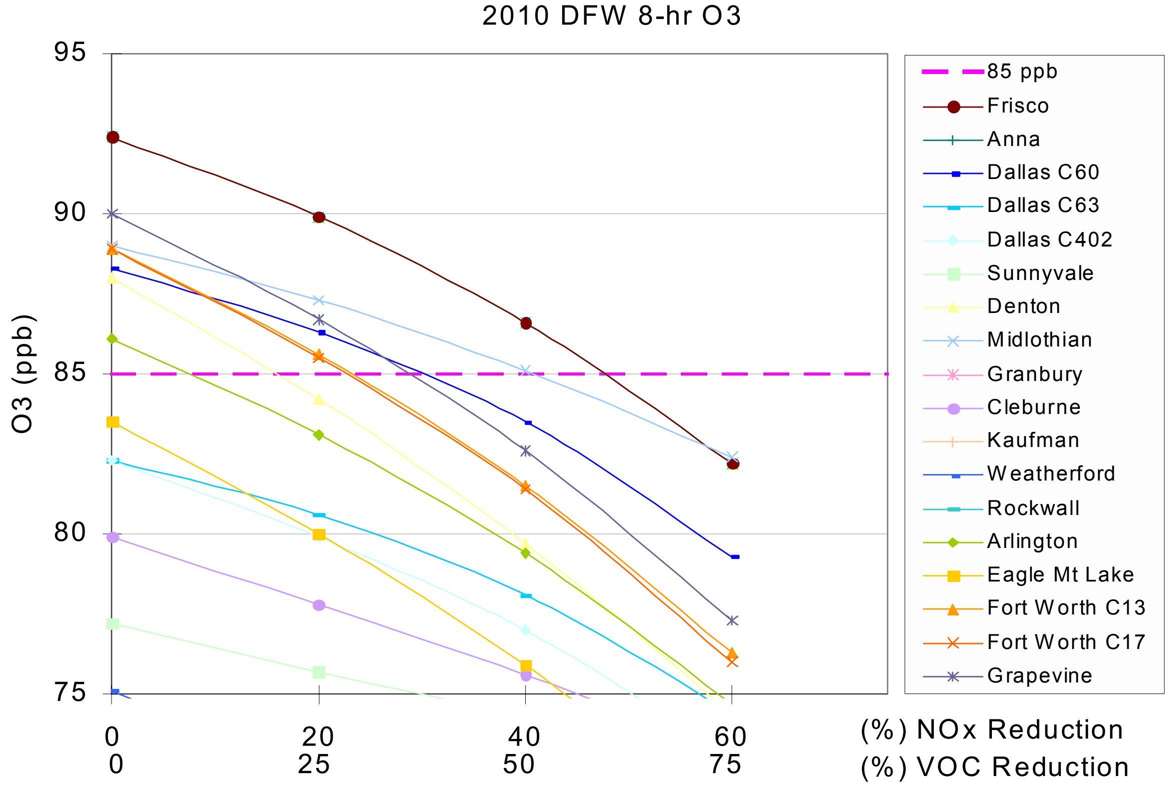


Figure 3-9. Eight-hour ozone response curves for NOx/VOC emission reduction scenarios.

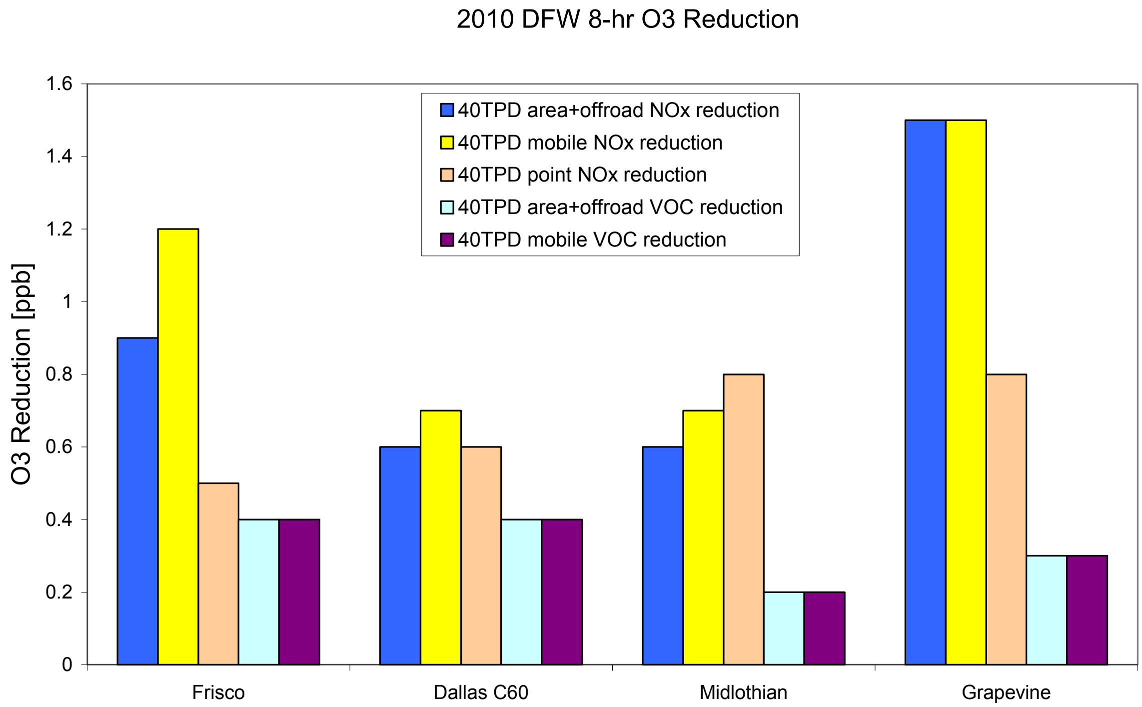


Figure 3-10. Eight-hour ozone responses to "40 top per day" emission reductions at four monitor locations.

4.0 OZONE SOURCE APPORTIONMENT (APCA) ANALYSIS

An ozone source apportionment analysis was completed for the 2010 base case to help understand which geographic areas and categories of emissions contribute to high ozone in the DFW area for the 2010 future case. A similar analysis completed for the 1999 base case by Mansell et al., (2003) was updated to be consistent with the 2010 analysis. The source apportionment analyses used a technique called APCA, which stands for Anthropogenic Precursor Culpability Assessment. The next section discusses how APCA results relate to other modeling methods, and the important points to realize are:

- Because ozone formation involves non-linear interactions between VOC and NOx emissions there is no unique source apportionment for ozone.
- Consequently, neither the APCA results nor any other modeling or ambient data analysis can provide a unique answer to the question "which emissions caused this ozone."
- We recommend considering all available information (modeling, inventories, data analysis) in developing a conceptual model of which sources cause high ozone and, therefore, how to design a control strategy.

METHODS FOR EVALUATING SOURCE CONTRIBUTIONS IN CAMx

Ambient measurements and ozone models both provide information on total ozone levels. Since ozone is formed from VOC and NOx precursor emissions it is useful to understand which emissions are causing high ozone levels so that effective emission control strategies can be designed. In other words, we would like to apportion the total ozone among all of the sources that participated in forming the ozone. Unfortunately, ozone source apportionment is difficult because ozone formation involves the interaction between emissions that likely came from different sources, e.g., anthropogenic NOx interacting with biogenic VOC. There is no one unique or "correct" way to apportion ozone among sources, but there are several approaches that can be used with CAMx:

- Ozone Source Apportionment Technology (OSAT).
- Anthropogenic Precursor Culpability Assessment (APCA).
- Zero-out differences.

CAMx also includes the decoupled direct method (DDM) method for sensitivity analysis (Dunker et al., 2002a). The DDM accurately calculates the sensitivity of model concentrations to emissions and is better suited to evaluating the effects of emissions changes (control strategies) than evaluating source contributions (source apportionment). The difference between source sensitivity and source apportionment is discussed further below.

Ozone Source Apportionment Technology (OSAT)

The OSAT method provides information about the relationships between ozone concentrations and sources of precursors in the form of ozone source apportionments. Source apportionment requires that the sum of all source contributions add up to exactly 100% of the total ozone so all of the ozone is accounted for. OSAT satisfies this requirement by attributing all new ozone production to precursors that are present at the point where the ozone is formed in CAMx. The OSAT attribution considers all potential sources of ozone in the simulation, i.e., emissions, boundary conditions and initial conditions. The emissions attribution can be broken out by geographic area and/or source category. The OSAT attribution of ozone production to the precursors that were present when the ozone was formed takes account of whether the ozone chemistry was sensitive to VOCs or NOx, and VOC reactivity differences. The OSAT methods are described in the CAMx User's Guide (ENVIRON, 2004) and in Dunker et al., (2002b).

Anthropogenic Precursor Culpability Assessment (APCA)

The APCA method is closely related to the OSAT method described above. The difference between the OSAT and APCA schemes can be summarized as follows. OSAT apportions ozone formation based solely on what precursors were present when the ozone is formed. APCA modifies the OSAT method to account for the fact that biogenic emissions are not considered to be controllable, and therefore APCA attributes ozone to controllable (anthropogenic) emissions whenever possible. The differences between OSAT and APCA are discussed in more detail below when results from the two methods are compared.

Zero-Out Differences

In the zero-out method the emissions for a particular source or group of sources are removed from the inventory (zeroed out), CAMx is re-run, and the change in ozone is measured relative to the base case. This zero-out ozone difference is a measure of the ozone contribution of the source, and the procedure can be repeated for several or all sources to build up a picture of relative source contributions to ozone. As discussed below, there are difficulties in interpreting the zero-out differences as source apportionments because the sum of the zero-out differences over all sources does not equal the total ozone. Nevertheless, the zero-out method has been widely used to evaluate source contributions to ozone.

STRENGTHS AND LIMITATIONS OF OSAT, APCA AND ZERO-OUT

As discussed above, there is no "correct" way to quantify the contribution of different source categories to ozone in a model like CAMx or in the real world. The OSAT, APCA and zero-out methods used with CAMx have different strengths and limitations that should be taken into account. The OSAT and APCA methods are discussed together because they are closely related.

The OSAT and APCA methods have several strengths:

- OSAT and APCA source contributions always sum to 100% of the modeled ozone so that all of the ozone is exactly accounted for and OSAT/APCA are directly interpretable as source apportionments.
- The OSAT and APCA apportionments are based on precursors from a specific source being present at the time and place where ozone was formed in the model.
- OSAT attributes ozone production based on whether the chemistry is VOC or NOx sensitive.
- The advantage of APCA over OSAT is taking account of the non-controllable nature of biogenic emissions. APCA seeks to minimize the contribution of biogenic sources (usually VOCs) by attributing ozone to the anthropogenic emissions (usually NOx) that interacted with the biogenic emissions.
- A practical advantage of OSAT and APCA is high computational efficiency, which means that more detailed source contributions (more geographic resolution, more source categories) can be identified with a set amount of project resources.

Limitations of OSAT and APCA are:

- Because ozone formation is non-linear, the OSAT and APCA source apportionments cannot be used to predict the effects of a specific strategy or calculate what emission reductions are needed to achieve a specific target ozone level.
- A limitation of OSAT can be attributing large amounts of ozone production to biogenic emission sources that are not controllable.

The strengths of the zero-out method are:

- The method is easy to explain and many people find the approach intuitively obvious and reasonable.
- The zero-out differences are directly related to the participation of emissions in ozone formation.
- The method is simple to apply with any model.

Limitations of the zero-out method are:

- The zero-out method requires changing the emissions, which in turn changes the chemistry of ozone formation.
- The sum of the zero-out differences over all sources will not necessarily add up to 100% of the modeled ozone.
- Zero-out differences may be negative for some sources. This makes sense in terms of source sensitivity, but does not make sense as source apportionment.
- For the three reasons listed above, zero-out results can be difficult to interpret as source apportionments. In this study, we refer to the zero-out results as differences rather than apportionments.
- A limitation of zero-out can be attributing large amounts of ozone production to biogenic emission sources that are not controllable.
- Because ozone formation is non-linear, the zero-out differences cannot be used to predict the effects of a specific strategy or calculate what emission reductions are needed to achieve a specific target ozone level. In particular, zeroing out all anthropogenic emissions represents an unrealistic control strategy which produces results that cannot be interpolated to correspond to a more modest (and realistic) strategy.

Source Apportionment vs. Source Sensitivity

An important limitation noted above that is common to OSAT, APCA and zero-out is that the results cannot be used to predict the effects of a specific strategy or calculate what emission reductions are needed to achieve a specific target ozone level. This is the difference between source apportionment and source sensitivity, which is an important technical issue that requires more explanation.

The amount of ozone formed by precursor emissions (NOx or VOC) is related to the amount of precursor emissions multiplied by the production efficiency i.e., ozone produced per precursor emitted. The ozone production efficiency is not a constant factor but depends upon many things, such as the type of emissions (NOx vs. VOC, specific type of VOC), the meteorological conditions, and the other precursors present in the atmosphere (e.g., the VOC/NOx ratio). As emissions are reduced, the ozone production efficiency also changes, and so the effect of emission controls may be greater or lesser than expected simply on the basis of the fraction of emissions reduced. In other words, a 10% emissions reduction will not necessarily lead to a 10% reduction in ozone contribution.

SOURCE AREAS AND EMISSIONS CATEGORIES

The geographic areas for the 2010 APCA analysis are the same as for the previously reported 1999 analysis (Mansell et al., 2003). The modeling domain was divided into 25 source areas described in Table 4-1 and shown in Figure 4-1. The emission inventory was divided into 4 source categories:

1. Biogenic sources
2. On-road mobile sources
3. All point sources (elevated plus low-level points)
4. Area plus off-road mobile sources.

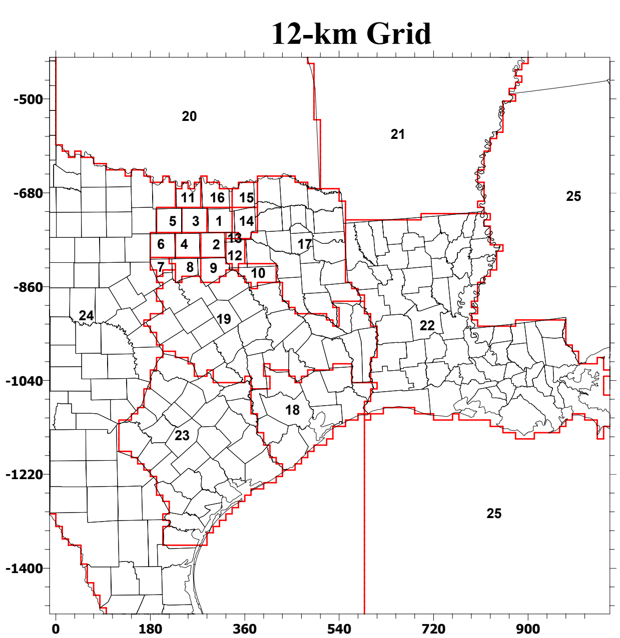
This means that APCA attributed ozone to 100 different sectors of the emission inventory (25 areas times 4 categories) plus the CAMx initial and boundary conditions (6 categories). Emission totals for the source categories and geographic areas used in the APCA analysis are given in Section 2 for 2010 and 1999 (Tables 2-8 to 2-10).

There are differences between the APCA analysis presented here and in Mansell et al. (2003):

- The point source group is now defined as all major point sources whereas it was previously just elevated points.
- The analyses presented here are based on updated meteorology and emissions and a newer version of CAMx.

Table 4-1. Emissions source area definitions.

Area Number	Area Abbreviation	DFW Core	DFW NAA	Area Definition
1	DFW Core	X	X	Collin Co.
2	DFW Core	X	X	Dallas Co.
3	DFW Core	X	X	Denton Co.
4	DFW Core	X	X	Tarrant Co.
5	Perimeter12			Wise Co.
6	Perimeter12		X	Parker Co.
7	Perimeter12			Hood Co.
8	Perimeter12		X	Johnson Co.
9	Perimeter12		X	Ellis Co.
10	Perimeter12			Henderson Co.
11	Perimeter12			Cooke Co.
12	Perimeter12		X	Kaufman Co.
13	Perimeter12		X	Rockwall Co.
14	Perimeter12			Hunt Co.
15	Perimeter12			Fannin Co.
16	Perimeter12			Grayson Co.
17	Northeast Texas			Northeast Texas
18	HGBPA			Houston/Galveston/Beaumont/Port-Arthur (11 Counties)
19	Central Texas			East Central Texas
20	OK			Oklahoma
21	AR			Arkansas
22	LA			Louisiana
23	South Texas			Near Non-attainment areas (Austin, San Antonio, Victoria, Corpus Christi)
24	West Texas			Texas (excluding area 1-19 and 23)
25	Other States			Other areas



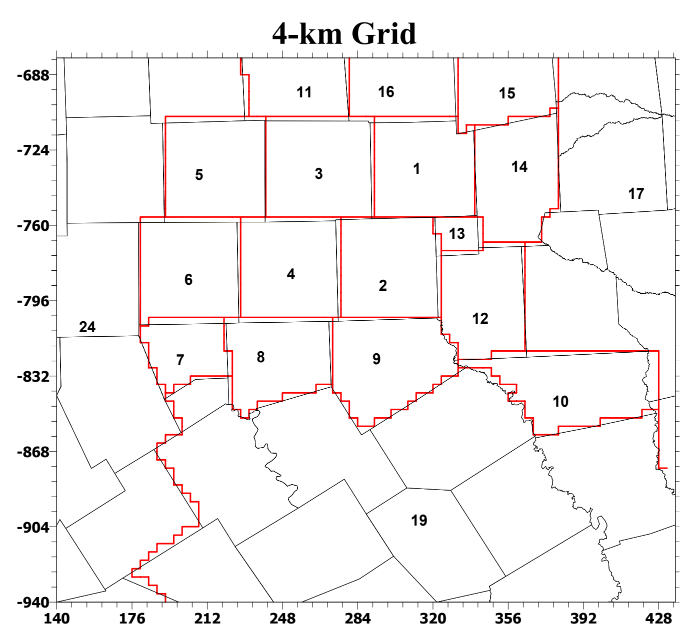


Figure 4-1. Geographic source areas for the 2010 APCA analysis. The areas are described in Table 4-1.

APCA RESULTS

The APCA analysis focused on identifying the anthropogenic emission sources that contribute to modeled 8-hour ozone levels of 85 ppb or higher in the four core DFW Counties and the 9 counties that comprise the DFW nonattainment area (NAA). The methodology for the "4 core county" analysis was:

1. Identify grid cells and hours in the four core DFW counties that had 1999 8-hour ozone levels of 85ppb or higher. There were 5241 grid cell-hours meeting these criteria on the August 15-22 modeling days (i.e., excluding two spin-up days).

2. Analyze the APCA results for 1999 and 2010 to calculate the average source contributions over these 5241 grid cell-hours.

This methodology was chosen to make the 1999 and 2010 results directly comparable because the averages are calculated over the same grid cells and hours in both years. A similar methodology was used for the "nine county NAA."

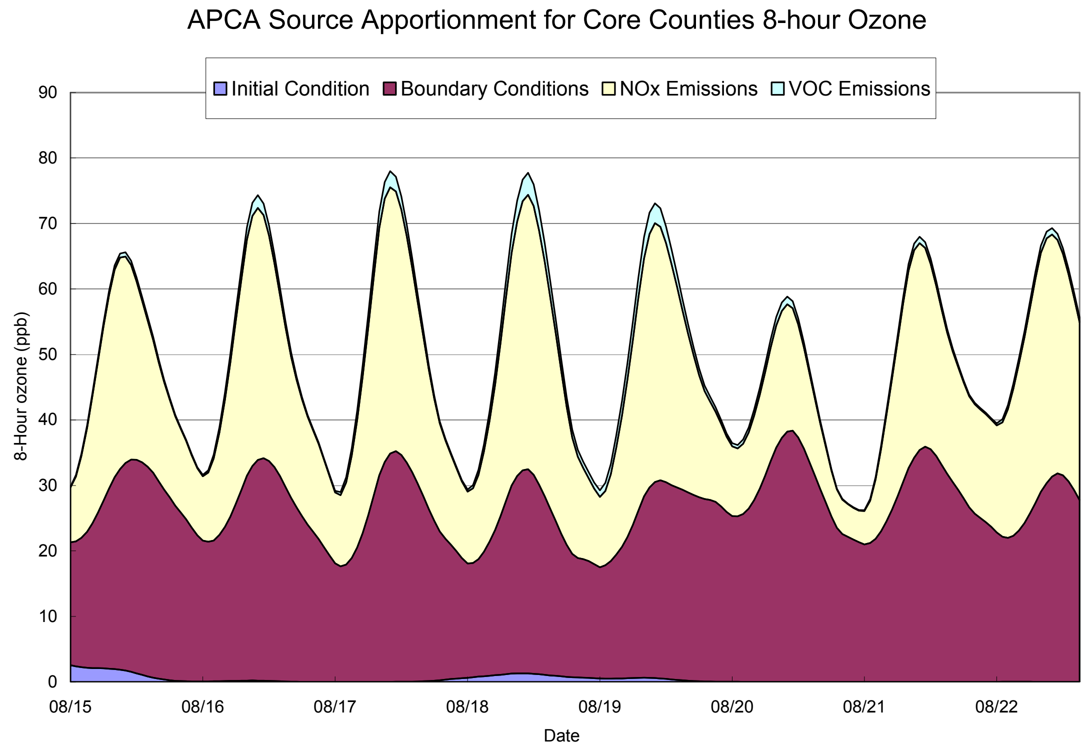
The APCA analysis was performed using CAMx version 4.03 for the 2010 base case (10run01b) described above and an updated 1999 base case (run17b) described by Emery et al. (2004). The differences between run17b and the previous 1999 APCA analysis (Mansell et. al., 2003) based on run7c were updated methodology and emissions (DFW mobile sources and Louisiana non-EGU points).

CONTRIBUTIONS TO 8-HOUR OZONE IN THE FOUR CORE DFW COUNTIES

The source contributions to 8-hour ozone in the four DFW core counties vary throughout the episode (August 15-22) as shown in Figure 4-2 for the 1999 base case (run17b). These figures show the daily cycle in total ozone which peaks around noon and reaches a minimum around midnight for 8-hour ozone (the time is the start of the 8-hour period). The main points from Figure 4-1 are:

- The contribution of initial conditions is small because of the two spin-up days (August 13-14).
- The contribution of boundary conditions is consistent throughout the episode and reaches a daytime peak of ~35 ppb each day.
- The contribution of biogenic emissions is small because APCA is designed to minimize biogenic contributions.
- The APCA biogenic emissions contribution results from the interaction of biogenic VOC <u>and</u> NOx and so is limited by the biogenic NOx emission levels.
- The contribution of NOx emissions is much greater than VOC emissions indicating that controlling NOx will be the most effective strategy for DFW. This result is consistent with the emissions sensitivity tests described in Section 3.
- The small contribution of VOC emissions is greater on the days with highest 8-hour ozone in the core counties (August 16-19) indicating more influence of VOC emissions on the most stagnant days.

- The contribution of NOx emissions to 8-hour ozone in the four core counties is split about evenly between on-road mobile, point sources and area plus off-road (when all source regions are aggregated).



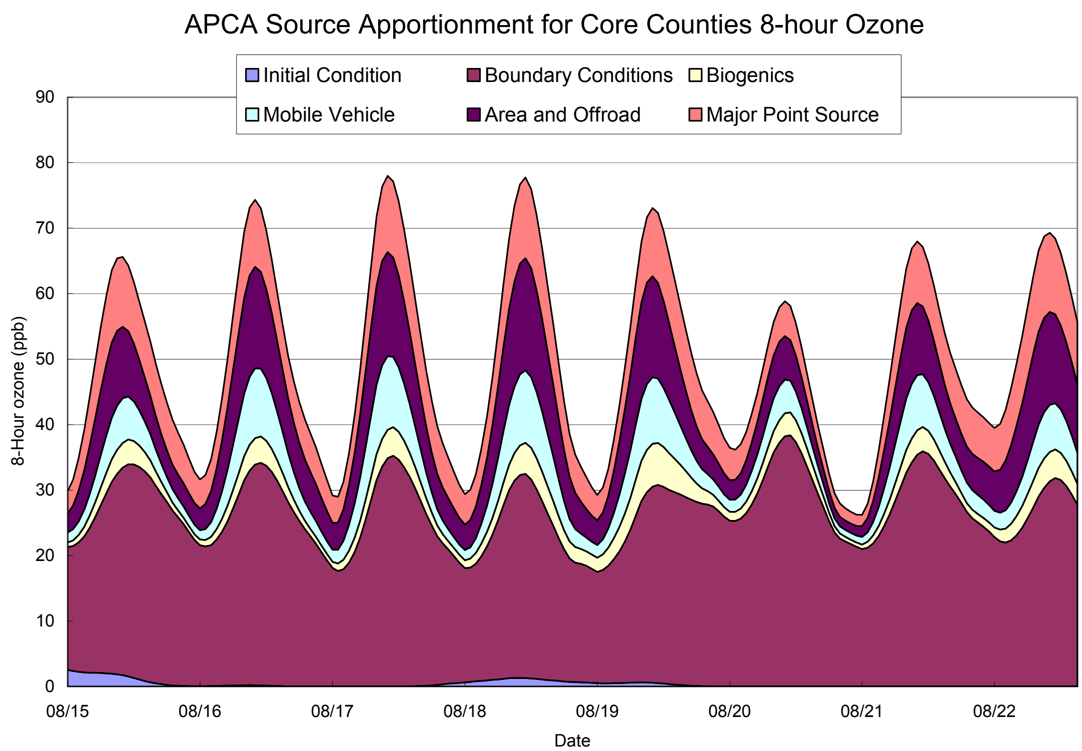


Figure 4-2. Time series of 1999 (run17b) source contributions to 8-hour ozone above 85 ppb in the four DFW core counties by NOx vs. VOC (top) and emissions category (bottom).

The average contributions to 8-hour ozone above 85 ppb in the four DFW counties are presented in Tables 4-2 to 4-4. Table 4-2 is for 2010, Table 4-3 is for 1999 and Table 4-4 shows the difference (2010-1999). The main findings are:

- The largest emissions contributions to high 8-hour ozone in the DFW 4-county area come from nearby emissions sources. Nearby means primarily emissions from within the 4-county DFW area, followed by surrounding counties (11 perimeter DFW counties), followed by neighboring parts of Texas (Central Texas and Northeast Texas).

- The relative importance of different emission source categories varies by region and year. For the 4 DFW core counties, on-road mobile sources and area plus off-road sources are the largest contributors, well ahead of point sources. For the surrounding 11 counties, these three anthropogenic source categories are more comparable with on-road mobile being the largest contributor in 1999, and point sources the largest contributor in 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the 4 Counties was 36.5 ppb in 1999 and 28.6 ppb in 2010. The reduction of 7.9 ppb was due to reduced contributions from on-road mobile and point sources offset partially by an increased contribution from area plus off-road sources. The increase in ozone contribution from area plus off-road sources was not due to higher emissions but, rather, due to more efficient ozone formation from area plus off-road source emissions as other sources (on-road and point) were reduced more aggressively in the DFW 4-county area.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the surrounding 11 counties was 4.1 ppb in 1999 and 4.7 ppb in 2010. The 0.6 ppb increase was due mostly to higher contributions from point sources in Ellis County (0.7 ppb increase) and Kaufman County (0.3+ ppb increase). The contribution of on-road sources from the surrounding 11 counties decreased from 1999 to 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from Northeast Texas was 3.4 ppb in 1999 and 2.5 ppb in 2010. The 0.9 ppb decrease was due to decreased contributions from point and on-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from Central Texas was 3.0 ppb in 1999 and 2.6 ppb in 2010. The 0.6 ppb decrease was due to decreased contributions from on-road and point sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from HGBPA was 1.4 ppb in 1999 and 1.0 ppb in 2010. The 0.4 ppb decrease was due to decreased contributions from on-road, point and area plus off-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from South Texas was 0.9 ppb in 1999 and 0.8 ppb in 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from West Texas was 0.2 ppb in 1999 and 0.1 ppb in 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from Louisiana was 4.1 ppb in 1999 and 3.8 ppb in 2010. The Louisiana contributions were mainly from area plus off-road and point sources ahead of mobile sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from Arkansas was 1.9 ppb in 1999 and 1.7 ppb in 2010. The Arkansas contributions were mainly from area plus off-road and point sources ahead of mobile sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from Oklahoma was 0.5 ppb in both 1999 and 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from other states (i.e., outside of Texas, Louisiana, Arkansas and Oklahoma) was 3.9 ppb in 1999 and 3.3 ppb in 2010.

- The contribution of model boundary conditions to high 8-hour ozone in the DFW 4-county area was about 33 ppb in both 2010 and 1999. This is consistent the value of 40 ppb used for the ozone boundary condition.

- The contribution of model initial conditions to high 8-hour ozone in the DFW 4-county area (after two spin-up days) was less than 1 ppb in both 2010 and 1999 which shows that control strategy development will not be influenced by the initial conditions.

Table 4-2. Average 2010 8-hour ozone contributions (ppb) to the four core DFW counties where 1999 8-hour ozone exceeded 85 ppb (results from 10run01b.APCA).

Source Region	Source Category										# cells = 5241	
	IC	BC East	BC North	BC South	BC Top	BC West	Biogenic	All Points	On-Road	Area + Off-Road	Grand Total	Area Total
Collin							0.21	0.10	0.68	0.86	**1.85**	
Dallas							0.21	1.47	4.88	6.25	**12.81**	
Denton							0.37	0.22	1.48	1.34	**3.41**	
Tarrant							0.17	0.81	3.97	5.60	**10.55**	**28.62**
Wise							0.01	0.03	0.02	0.09	**0.15**	
Parker							0.01	0.03	0.04	0.04	**0.12**	
Hood							0.00	0.18	0.00	0.01	**0.19**	
Johnson							0.07	0.07	0.12	0.23	**0.49**	
Ellis							0.19	1.54	0.18	0.29	**2.20**	
Henderson							0.01	0.05	0.02	0.08	**0.16**	
Cooke							0.02	0.00	0.01	0.01	**0.04**	
Kaufman							0.16	0.34	0.19	0.14	**0.83**	
Rockwall							0.05	0.00	0.09	0.06	**0.20**	
Hunt							0.03	0.00	0.03	0.02	**0.08**	
Fannin							0.02	0.00	0.00	0.00	**0.02**	
Grayson							0.05	0.10	0.04	0.04	**0.23**	**4.71**
Central Texas							0.69	0.82	0.35	0.73	**2.59**	
Northeast Texas							0.19	1.06	0.41	0.86	**2.52**	
South Texas							0.21	0.20	0.15	0.21	**0.77**	
HGBPA							0.10	0.32	0.24	0.29	**0.95**	
West Texas							0.04	0.04	0.01	0.05	**0.14**	**6.97**
AR							0.23	0.78	0.18	0.55	**1.74**	
LA							0.33	1.53	0.34	1.60	**3.80**	
OK							0.07	0.20	0.08	0.10	**0.45**	
Other States							0.43	1.49	0.39	1.01	**3.32**	**9.31**
Boundary Conditions		0.27	9.79	0.39	0.81	20.98					**32.24**	
Initial Conditions	0.67										**0.67**	**32.91**
Grand Total	**0.67**	**0.27**	**9.79**	**0.39**	**0.81**	**20.98**	**3.87**	**11.38**	**13.90**	**20.46**	**82.52**	**82.52**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Table 4-3. Average 1999 8-hour ozone contributions (ppb) to the four core DFW counties where 1999 8-hour ozone exceeded 85 ppb (results from 99run17b.APCA).

	Source Category										# cells = 5241	
Source Region	**IC**	**BC East**	**BC North**	**BC South**	**BC Top**	**BC West**	**Biogenic**	**All Points**	**On-Road**	**Area + Off-Road**	**Grand Total**	**Area Total**
Collin							0.10	0.12	0.89	0.96	**2.07**	
Dallas							0.12	2.77	8.19	6.15	**17.23**	
Denton							0.23	0.30	2.26	1.51	**4.30**	
Tarrant							0.10	1.20	6.59	5.04	**12.93**	**36.53**
Wise							0.01	0.03	0.02	0.11	**0.17**	
Parker							0.01	0.01	0.08	0.06	**0.16**	
Hood							0.00	0.23	0.01	0.01	**0.25**	
Johnson							0.04	0.07	0.24	0.24	**0.59**	
Ellis							0.12	0.81	0.38	0.22	**1.53**	
Henderson							0.01	0.04	0.03	0.07	**0.15**	
Cooke							0.01	0.00	0.02	0.01	**0.04**	
Kaufman							0.11	0.02	0.36	0.18	**0.67**	
Rockwall							0.03	0.00	0.14	0.05	**0.22**	
Hunt							0.03	0.00	0.06	0.02	**0.11**	
Fannin							0.01	0.00	0.00	0.00	**0.01**	
Grayson							0.03	0.05	0.06	0.04	**0.18**	**4.08**
Central Texas							0.55	1.06	0.66	0.68	**2.95**	
Northeast Texas							0.19	1.66	0.74	0.85	**3.44**	
South Texas							0.16	0.23	0.27	0.24	**0.90**	
HGBPA							0.07	0.53	0.44	0.31	**1.35**	
West Texas							0.03	0.03	0.02	0.06	**0.14**	**8.78**
AR							0.20	0.75	0.32	0.63	**1.90**	
LA							0.28	1.56	0.60	1.68	**4.12**	
OK							0.05	0.14	0.11	0.16	**0.46**	
Other States							0.35	1.98	0.59	0.93	**3.85**	**10.33**
Boundary Conditions		0.27	10.04	0.36	0.82	20.54					**32.03**	
Initial Conditions	0.68										**0.68**	**32.71**
Grand Total	**0.68**	**0.27**	**10.04**	**0.36**	**0.82**	**20.54**	**2.84**	**13.59**	**23.08**	**20.21**	**92.43**	**92.43**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Table 4-4. Difference (2010 - 1999) in average 8-hour ozone contributions (ppb) to the four core DFW counties where 1999 8-hour ozone exceeded 85 ppb.

Source Region	Source Category										# cells = 5241	
	IC	BC East	BC North	BC South	BC Top	BC West	Biogenic	All Points	On-Road	Area + Off-Road	Grand Total	Area Total
Collin							0.11	-0.02	-0.21	-0.10	**-0.22**	
Dallas							0.09	-1.30	-3.31	0.10	**-4.42**	
Denton							0.14	-0.08	-0.78	-0.17	**-0.89**	
Tarrant							0.07	-0.39	-2.62	0.56	**-2.38**	**-7.91**
Wise							0.00	0.00	0.00	-0.02	**-0.02**	
Parker							0.00	0.02	-0.04	-0.02	**-0.04**	
Hood							0.00	-0.05	-0.01	0.00	**-0.06**	
Johnson							0.03	0.00	-0.12	-0.01	**-0.10**	
Ellis							0.07	0.73	-0.20	0.07	**0.67**	
Henderson							0.00	0.01	-0.01	0.01	**0.01**	
Cooke							0.01	0.00	-0.01	0.00	**0.00**	
Kaufman							0.05	0.32	-0.17	-0.04	**0.16**	
Rockwall							0.02	0.00	-0.05	0.01	**-0.02**	
Hunt							0.00	0.00	-0.03	0.00	**-0.03**	
Fannin							0.01	0.00	0.00	0.00	**0.01**	
Grayson							0.02	0.05	-0.02	0.00	**0.05**	**0.63**
Central Texas							0.14	-0.24	-0.31	0.05	**-0.36**	
Northeast Texas							0.00	-0.60	-0.33	0.01	**-0.92**	
South Texas							0.05	-0.03	-0.12	-0.03	**-0.13**	
HGBPA							0.03	-0.21	-0.20	-0.02	**-0.40**	
West Texas							0.01	0.01	-0.01	-0.01	**0.00**	**-1.81**
AR							0.03	0.03	-0.14	-0.08	**-0.16**	
LA							0.05	-0.03	-0.26	-0.08	**-0.32**	
OK							0.02	0.06	-0.03	-0.06	**-0.01**	
Other States							0.08	-0.49	-0.20	0.08	**-0.53**	**-1.02**
Boundary Conditions		0.00	-0.25	0.03	-0.01	0.44					**0.21**	
Initial Conditions	-0.01										**-0.01**	**0.20**
Grand Total	**-0.01**	**0.00**	**-0.25**	**0.03**	**-0.01**	**0.44**	**1.03**	**-2.21**	**-9.18**	**0.25**	**-9.91**	**-9.91**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

CONTRIBUTIONS TO HIGH 8-HOUR OZONE IN THE NINE DFW NAA COUNTIES

The average contributions to 8-hour ozone above 85 ppb in the nine nonattainment area (NAA) counties are presented in Tables 4-5 to 4-7. These tables correspond to Tables 4-2 to 4-4 discussed above for the four core counties. The source contributions for the four and nine county DFW areas are very similar and the findings for the four county area are not repeated again here. The main difference for the nine county area is higher contribution (~2 ppb higher) from the DFW surrounding 11 counties offset by a lower (~2 ppb lower) contribution from the four core counties.

Table 4-5. Average 2010 8-hour ozone contributions (ppb) to the nine DFW NAA counties where 1999 8-hour ozone exceeded 85 ppb (results from 10run01b.APCA).

Source Region	Source Category										# cells = 8208	
	IC	BC East	BC North	BC South	BC Top	BC West	Biogenic	All Points	On-Road	Area + Off-Road	Grand Total	Area Total
Collin							0.18	0.08	0.53	0.68	**1.47**	
Dallas							0.23	1.30	4.34	5.53	**11.40**	
Denton							0.27	0.16	1.08	1.00	**2.51**	
Tarrant							0.19	1.02	4.13	5.74	**11.08**	**26.46**
Wise							0.01	0.06	0.02	0.13	**0.22**	
Parker							0.03	0.13	0.18	0.15	**0.49**	
Hood							0.01	0.26	0.01	0.01	**0.29**	
Johnson							0.15	0.09	0.20	0.35	**0.79**	
Ellis							0.32	1.87	0.25	0.40	**2.84**	
Henderson							0.01	0.05	0.02	0.07	**0.15**	
Cooke							0.02	0.00	0.02	0.02	**0.06**	
Kaufman							0.17	0.33	0.18	0.13	**0.81**	
Rockwall							0.04	0.00	0.08	0.05	**0.17**	
Hunt							0.04	0.00	0.03	0.02	**0.09**	
Fannin							0.03	0.00	0.01	0.01	**0.05**	
Grayson							0.06	0.11	0.05	0.06	**0.28**	**6.24**
Central Texas							0.80	0.82	0.37	0.76	**2.75**	
Northeast Texas							0.19	1.02	0.41	0.80	**2.42**	
South Texas							0.31	0.28	0.26	0.33	**1.18**	
HGBPA							0.10	0.34	0.27	0.32	**1.03**	
West Texas							0.09	0.07	0.03	0.09	**0.28**	**7.66**
AR							0.19	0.68	0.16	0.48	**1.51**	
LA							0.27	1.30	0.28	1.37	**3.22**	
OK							0.09	0.25	0.10	0.12	**0.56**	
Other States							0.39	1.36	0.36	0.93	**3.04**	**8.33**
Boundary Conditions		0.27	8.90	1.06	0.78	21.16					**32.17**	
Initial Conditions	0.67										**0.67**	**32.84**
Grand Total	**0.67**	**0.27**	**8.90**	**1.06**	**0.78**	**21.16**	**4.19**	**11.58**	**13.37**	**19.55**	**81.53**	**81.53**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Table 4-6. Average 1999 8-hour ozone contributions (ppb) to the nine DFW NAA counties where 1999 8-hour ozone exceeded 85 ppb (results from 99run17b.APCA).

	Source Category										# cells = 8208	
Source Region	**IC**	**BC East**	**BC North**	**BC South**	**BC Top**	**BC West**	**Biogenic**	**All Points**	**On-Road**	**Area + Off-Road**	**Grand Total**	**Area Total**
Collin							0.09	0.11	0.73	0.77	**1.70**	
Dallas							0.14	2.49	7.47	5.50	**15.60**	
Denton							0.17	0.22	1.67	1.10	**3.16**	
Tarrant							0.11	1.70	7.04	5.33	**14.18**	**34.64**
Wise							0.01	0.05	0.04	0.18	**0.28**	
Parker							0.02	0.07	0.35	0.31	**0.75**	
Hood							0.00	0.32	0.02	0.03	**0.37**	
Johnson							0.11	0.10	0.41	0.41	**1.03**	
Ellis							0.24	1.02	0.53	0.30	**2.09**	
Henderson							0.01	0.03	0.03	0.07	**0.14**	
Cooke							0.01	0.00	0.02	0.02	**0.05**	
Kaufman							0.12	0.02	0.35	0.17	**0.66**	
Rockwall							0.03	0.00	0.12	0.04	**0.19**	
Hunt							0.03	0.00	0.06	0.03	**0.12**	
Fannin							0.02	0.00	0.01	0.01	**0.04**	
Grayson							0.04	0.09	0.09	0.06	**0.28**	**6.00**
Central Texas							0.66	1.14	0.71	0.74	**3.25**	
Northeast Texas							0.18	1.61	0.76	0.79	**3.34**	
South Texas							0.25	0.32	0.49	0.39	**1.45**	
HGBPA							0.07	0.60	0.51	0.37	**1.55**	
West Texas							0.06	0.08	0.04	0.14	**0.32**	**9.91**
AR							0.17	0.64	0.29	0.55	**1.65**	
LA							0.23	1.31	0.50	1.41	**3.45**	
OK							0.07	0.19	0.16	0.22	**0.64**	
Other States							0.32	1.79	0.55	0.86	**3.52**	**9.26**
Boundary Conditions		0.27	9.08	1.05	0.78	20.81					**31.99**	
Initial Conditions	0.68										**0.68**	**32.67**
Grand Total	**0.68**	**0.27**	**9.08**	**1.05**	**0.78**	**20.81**	**3.16**	**13.90**	**22.95**	**19.80**	**92.48**	**92.48**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Table 4-7. Difference (2010 - 1999) in average 8-hour ozone contributions (ppb) to the nine DFW NAA counties where 1999 8-hour ozone exceeded 85 ppb.

	Source Category										# cells = 8208	
Source Region	**IC**	**BC East**	**BC North**	**BC South**	**BC Top**	**BC West**	**Biogenic**	**All Points**	**On-Road**	**Area + Off-Road**	**Grand Total**	**Area Total**
Collin							0.09	-0.03	-0.20	-0.09	**-0.23**	
Dallas							0.09	-1.19	-3.13	0.03	**-4.20**	
Denton							0.10	-0.06	-0.59	-0.10	**-0.65**	
Tarrant							0.08	-0.68	-2.91	0.41	**-3.10**	**-8.18**
Wise							0.00	0.01	-0.02	-0.05	**-0.06**	
Parker							0.01	0.06	-0.17	-0.16	**-0.26**	
Hood							0.01	-0.06	-0.01	-0.02	**-0.08**	
Johnson							0.04	-0.01	-0.21	-0.06	**-0.24**	
Ellis							0.08	0.85	-0.28	0.10	**0.75**	
Henderson							0.00	0.02	-0.01	0.00	**0.01**	
Cooke							0.01	0.00	0.00	0.00	**0.01**	
Kaufman							0.05	0.31	-0.17	-0.04	**0.15**	
Rockwall							0.01	0.00	-0.04	0.01	**-0.02**	
Hunt							0.01	0.00	-0.03	-0.01	**-0.03**	
Fannin							0.01	0.00	0.00	0.00	**0.01**	
Grayson							0.02	0.02	-0.04	0.00	**0.00**	**0.24**
Central Texas							0.14	-0.32	-0.34	0.02	**-0.50**	
Northeast Texas							0.01	-0.59	-0.35	0.01	**-0.92**	
South Texas							0.06	-0.04	-0.23	-0.06	**-0.27**	
HGBPA							0.03	-0.26	-0.24	-0.05	**-0.52**	
West Texas							0.03	-0.01	-0.01	-0.05	**-0.04**	**-2.25**
AR							0.02	0.04	-0.13	-0.07	**-0.14**	
LA							0.04	-0.01	-0.22	-0.04	**-0.23**	
OK							0.02	0.06	-0.06	-0.10	**-0.08**	
Other States							0.07	-0.43	-0.19	0.07	**-0.48**	**-0.93**
Boundary Conditions		0.00	-0.18	0.01	0.00	0.35					**0.18**	**0.00**
Initial Conditions	-0.01										**-0.01**	**0.17**
Grand Total	**-0.01**	**0.00**	**-0.18**	**0.01**	**0.00**	**0.35**	**1.03**	**-2.32**	**-9.58**	**-0.25**	**-10.95**	**-10.95**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

CONTRIBUTIONS TO HIGH 8-HOUR OZONE AT SPECIFIC MONITOR LOCATIONS

The APCA results for 2010 were analyzed at monitor locations for use in conjunction with the 2010 “design value scaling.” As discussed in Section 3, “DV scaling” is the method developed by EPA for 8-hour ozone attainment demonstrations (EPA, 1999). The DV scaling method applied to DFW monitor locations looked at the daily maximum 8-hour ozone in a 7 x 7 block of grid cells around the monitor, averaged over all days above 70 ppb. The 2010 APCA results were analyzed by the same method to give a source apportionment of the DV scaling calculation at each monitor. The results are shown in Figures 4-3 to 4-6 for the four hardest to control monitors; (Frisco, Dallas CAMS60, Midlothian and Grapevine (see Section 3 and Figure 3-7). In these figures, “other anthro” means area plus off-road mobile sources.

The main findings from the APCA analysis for the four hardest to control monitors are:

- Dallas County is the highest contributing source area at three of the four monitors (Frisco, CAMS60 and Grapevine).
- Ellis County is the highest contributing source area at the Midlothian monitor.
- Dallas County contributions are dominated by area plus off-road and on-road mobile

(NOx) emissions.
- Ellis County contributions are dominated by point source (NOx) emissions.
- Transport from outside the DFW nine county area is relatively more important at Midlothian than the other three monitors.

The monitor location analyses presented in Figures 4-3 to 4-6 are a composite of several days (days from August 15-22 above 70 ppb, see Table 3-4 for details). The source contributions at monitors vary from day-to-day, mainly due to meteorology, and this is illustrated for the Grapevine monitor on August 19 and 20 in Figure 4-7. On August 19, the Grapevine monitor is mainly influenced by Dallas and Tarrant County emissions, but on August 20 when winds are more northerly the top two contributing areas are Denton and Tarrant Counties. This example is presented to illustrate how source contributions can vary from day-to-day. However, because the EPA design values scaling methodology is based on a composite of days, the composite analyses presented in Figure 4-3 to 4-6 are most relevant.

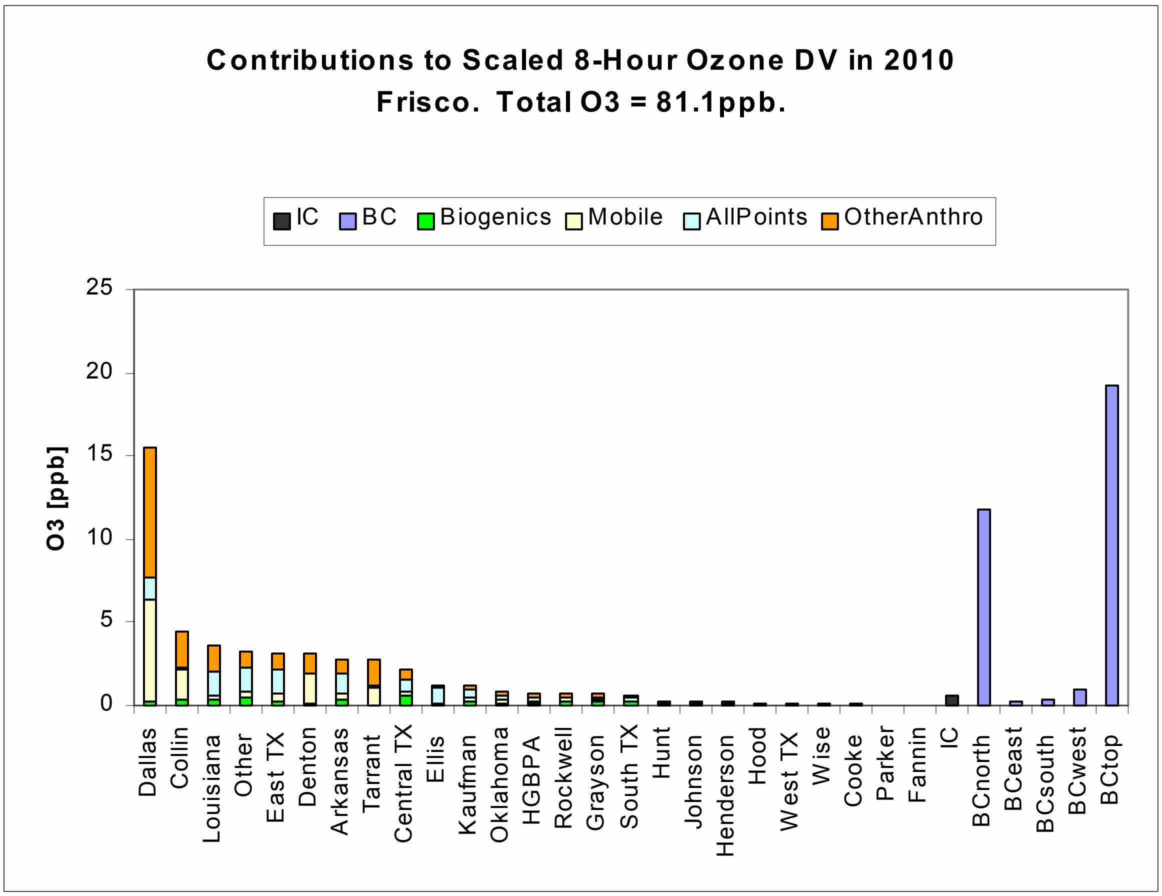


Figure 4-3. APCA analysis of contributions to the scaled 8-hour ozone design value for 2010 at the Frisco monitor.

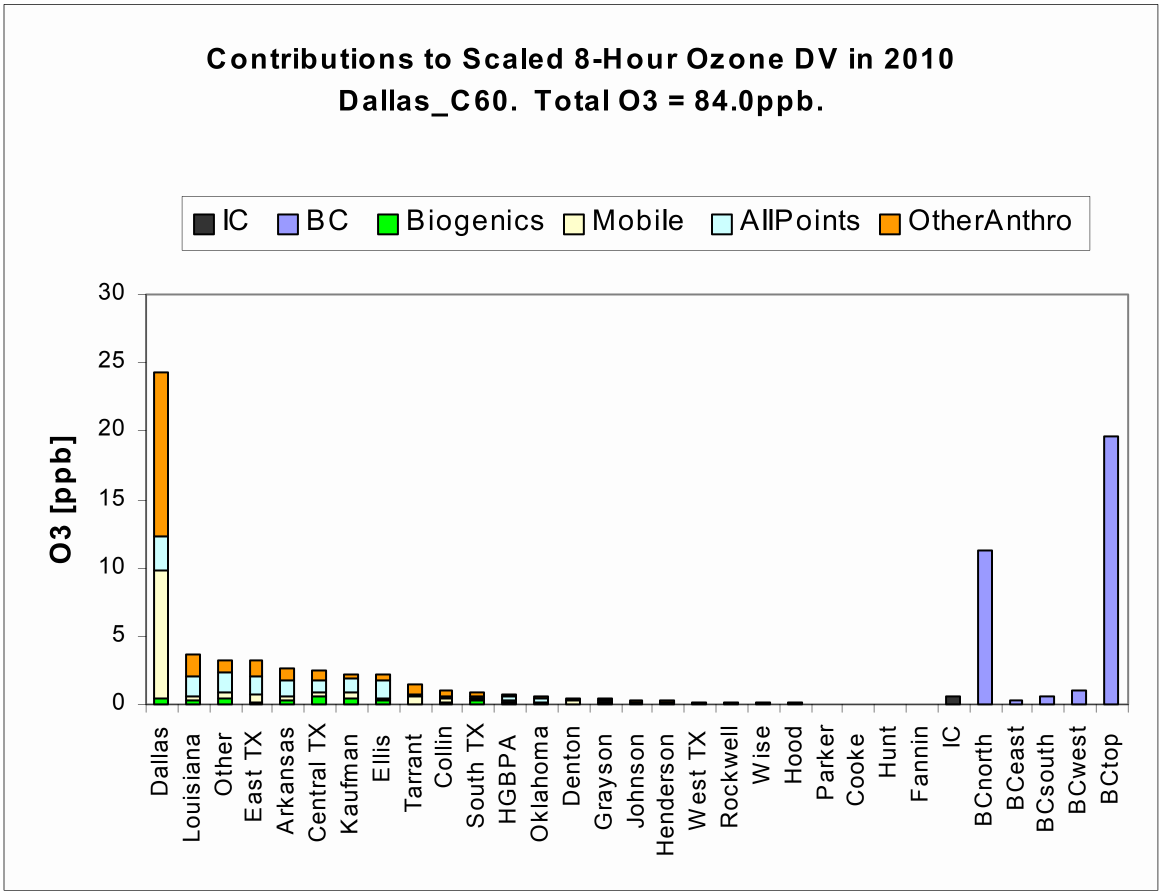


Figure 4-4. APCA analysis of contributions to the scaled 8-hour ozone design value for 2010 at the Dallas CAMS60 monitor.

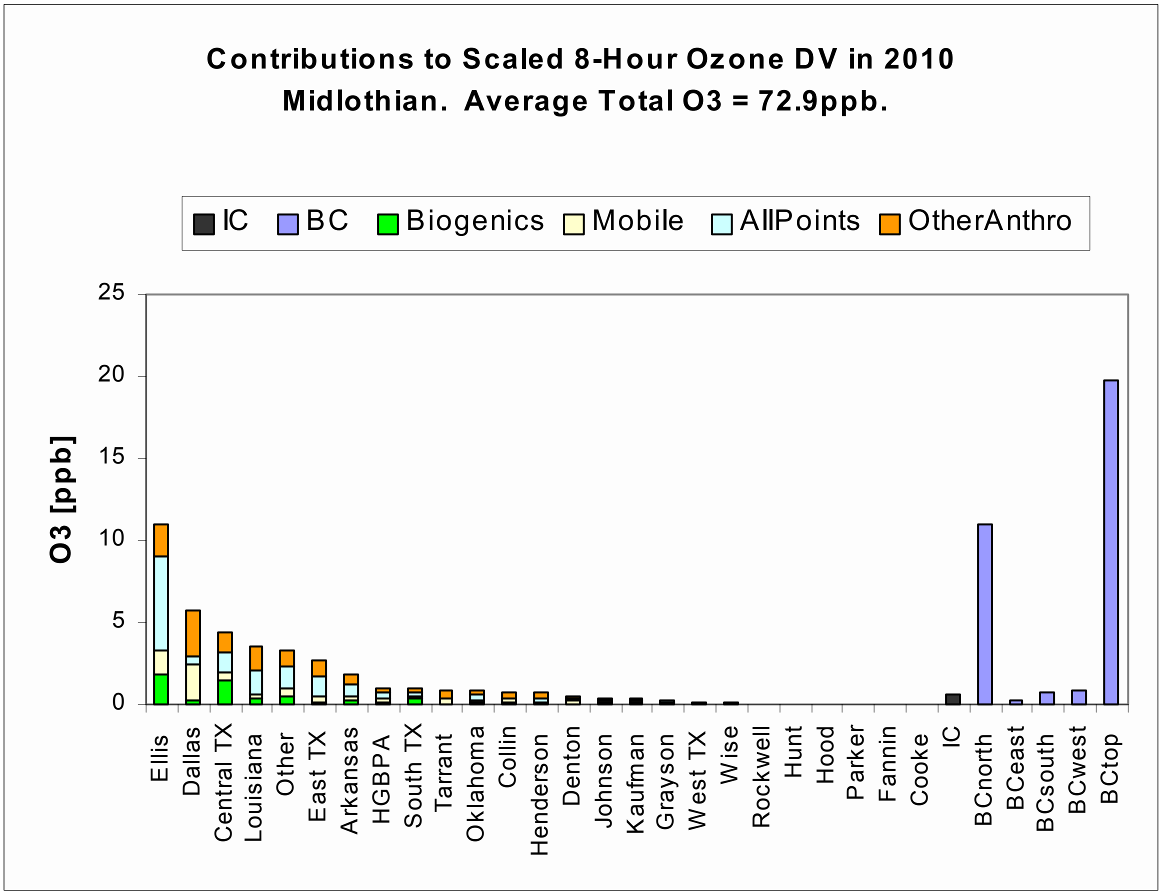


Figure 4-5. APCA analysis of contributions to the scaled 8-hour ozone design value for 2010 at the Midlothian monitor.

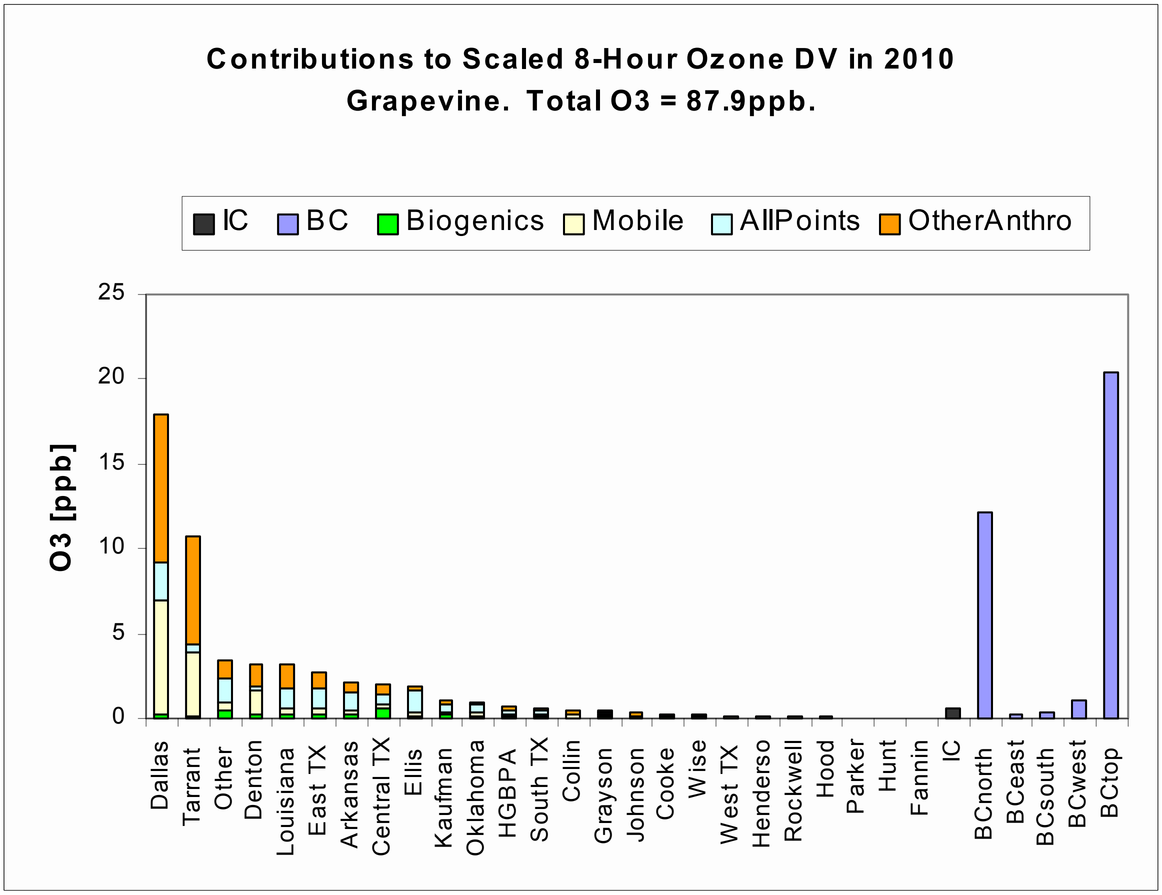


Figure 4-6. APCA analysis of contributions to the scaled 8-hour ozone design value for 2010 at the Grapevine monitor.

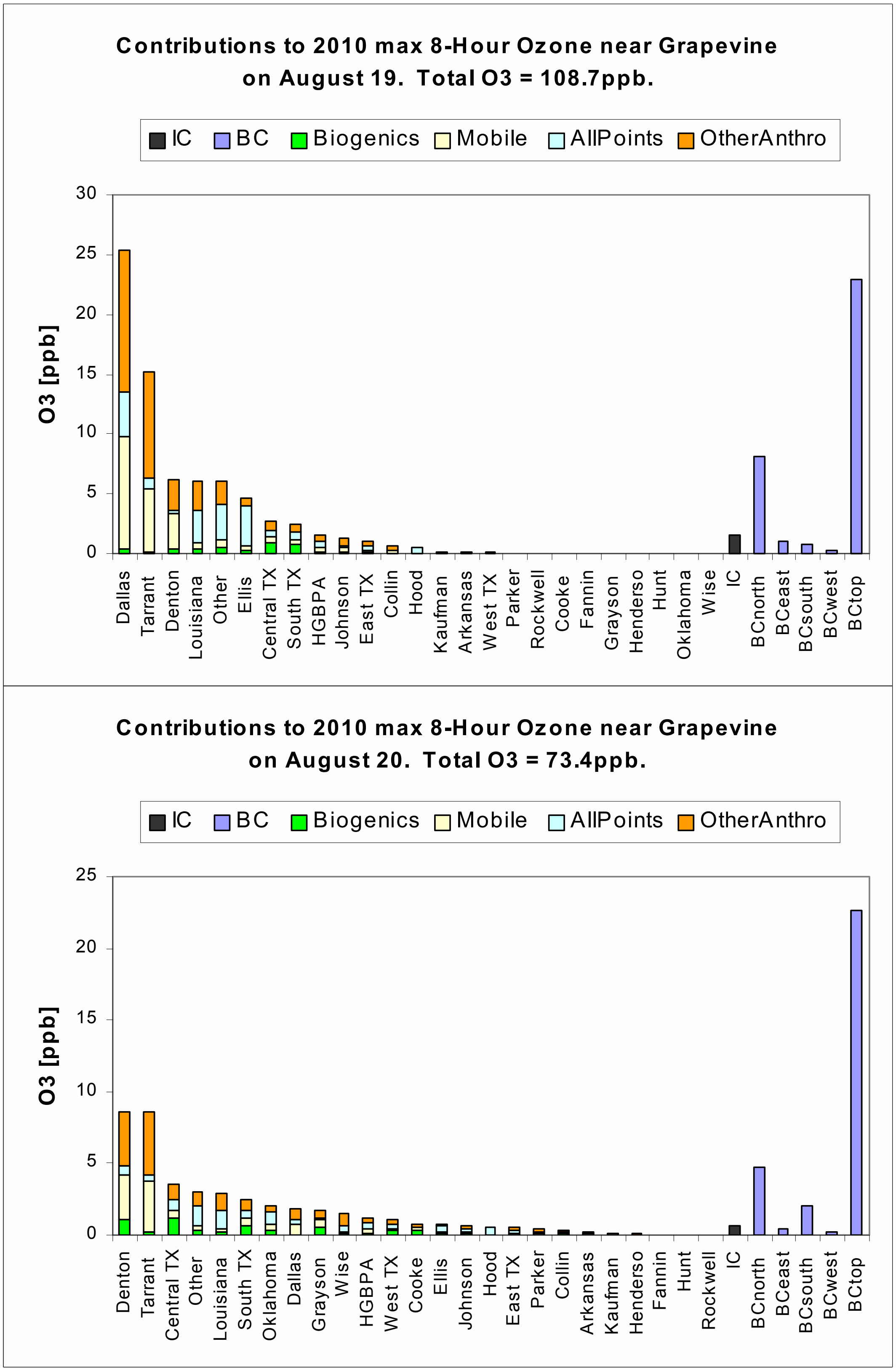


Figure 4-7. APCA analysis of contributions to the 2010 maximum 8-hour ozone near the Grapevine monitor on August 19th (top) and August 20th (bottom).

5.0 SUMMARY

The CAMx air quality model was applied for the August 13 – 22, 1999 Dallas/Ft. Worth ozone episode. Version 4.03 of the CAMx air quality model was run for the 1999 base year and the 2010 future year. The development of the input databases for 1999 was documented in Mansell et al., 2003 and Emery et al., 2004. Emission inventories for the 2010 future year were developed jointly by ENVIRON and TCEQ as described above. Modeling results and performance evaluation of the 1999 base case was presented in Emery et al., 2004. The main points from the ozone modeling results 2010 are summarized below.

8-HOUR OZONE FOR 2010

Results of the future year ozone modeling for 2010 were presented in Section 3. Predicted daily maximum 8-hour ozone concentrations were presented in Table 3-2 for the 4-km DFW modeling domain. While broad regions of ozone reductions in 2010 are realized throughout the modeling domain, some areas of ozone increases due to "NOx disbenefits", ranging from a few ppb to approximately 13 ppb, are seen in the Dallas urban core. However, these disbenefits did not occur for the 2010 design value calculations, discussed below. On most episode days, the locations the 8-hour ozone peaks are shifted towards the urban core area in 2010 relative to 1999.

The 2010 design value scaling methodology from EPA's 8-hour draft modeling guidance (EPA, 1999) was presented and discussed in Section 3. Design values for 8-hour ozone in 2010 were shown in Table 3-3. The results of the design value scaling analysis were presented in Table 3-4.

The design value scaling for the 2010 future year can be summarized as follows:

- An analysis was completed for 8-hour ozone levels in 2010 using EPA's design value (DV) scaling methodology.

- The projected 8-hour design values for 2010 exceeded the target level of 84 ppb (after truncation) at 8 of 18 monitor locations in the DFW area. There were no other locations (screening cells) that needed to be considered.

- The relative reduction factor analysis projected that only four monitors (Dallas C402, Cleburne, Weatherford and Eagle Mt Lake) would come into attainment of the 8-hour ozone standard by 2010.

- The highest projected 8-hour design value for 2010 was 92.4 ppb at the Frisco monitor.

- There were no increases in monitor design values ("NOx disbenefits") between 1999 and 2010.

EMISSION REDUCTION SENSITIVITY TESTS FOR 2010

A series of emission reduction sensitivity tests for 2010 were considered in order to provide "directional guidance" in developing control measure to address the 8-hour ozone standard.

Both NOx and VOC emissions reductions were considered. The reductions were applied within the 9-county DFW area to all anthropogenic emissions ("across the board"), as well as to specific source categories at a defined emissions reduction level ("40 ton per day"). The specific emission reduction scenarios and the development of the emission inventories were described in Section 3.

The following findings are based on the results of the "across the board" emission reduction sensitivity tests presented in Table 3-7 and Figures 3-7 through 3-9:

- NOx controls are more effective than VOC controls in reducing 8-hour ozone at all monitors in the DFW area, although VOC emission reductions do contribute slightly to reducing the 8-hour ozone concentrations.

- About 50% "across the board" NOx reduction in the 9-County area is needed to bring the highest ozone monitor into 8-hour ozone attainment (i.e., below 85 ppb).

- The four monitors that are hardest to bring into 8-hour ozone attainment with "across the board" NOx reductions are Frisco, Midlothian, Dallas CAMS-60 and Grapevine.

- There are no "NOx disbenefits" in the responses of 8-hour ozone design values to NOx control, i.e., there are no increases in 8-hour ozone design values resulting from NOx controls.

- The Frisco monitor is the hardest to bring into 8-hour ozone attainment using "across the board" NOx reductions. Frisco is responsive to NOx reductions in the 9-County area but is the hardest monitor to control because it has the highest design value in the 2010 base case.

- Several monitors (i.e., CAMS63 and CAMS60) respond poorly to NOx reductions at about the 20% level, although these monitors respond well to deeper NOx reductions. This poor initial response to NOx reduction is likely due to the proximity of these monitors to areas of "NOx disbenefit" seen between 1999 and 2010 near the Dallas urban core.

- The Midlothian monitor is less responsive to across the board NOx emission reductions in the 9-County area than other monitors and, consequently, is among the hardest to bring into 8-hour ozone attainment. This poor response is likely because the Midlothian monitor is upwind of the majority of the emission reductions on most of the episode days. The standard EPA design value scaling approach may not work well for the Midlothian monitor.

- The emissions reduction scenarios are for region-wide emissions reductions – source-specific reductions might be more or less effective at specific monitor locations.

The following findings are based on the results of the "40 ton per day" emission reduction sensitivity tests presented in Table 3-8 and Figure 3-10:

- NOx reductions are more effective than VOC reductions at lowering ozone at all four "hardest to control" monitors (Frisco, CAMS-60, Midlothian and Grapevine).

- NOx reductions from point sources are less effective at lowering ozone than NOx reductions from on-road, off-road or area sources at the Frisco and Grapevine monitor locations.

- NOx reductions from all sources are about equally effective at lowering ozone at the Dallas CAMS60 and Midlothian monitor locations.

- Because there are differences between monitors, control strategy designs can be made more effective by accounting for the specific sources that influence ozone at each monitor.

OZONE SOURCE APPORTIONMENT (APCA) ANALYSIS FOR 2010

An ozone source apportionment analysis was completed for the 2010 future case to help understand which geographic areas and categories of emissions contribute to high ozone in the DFW area for the 2010 future case. A discussion of the source apportionment technique and the analysis for the 2010 future year case was presented in Section 4. The source apportionment analyses used a technique called APCA, which stands for Anthropogenic Precursor Culpability Assessment.

The source contributions to 8-hour ozone in the four DFW core counties, presented and discussed in Section 4, can be summarized as follows:

- The contribution of initial conditions is small because of the two spin-up days (August 13-14) while the contribution of boundary conditions is consistent throughout the episode and reaches a daytime peak of ~35 ppb each day.

- The contribution of biogenic emissions is small because APCA is designed to minimize the "non-controllable" contribution from biogenic contributions. The APCA biogenic emissions contributions result from the interaction of biogenic VOC and NOx and so are limited by the biogenic NOx emission levels.

- The contribution of NOx emissions is much greater than VOC emissions indicating that controlling NOx will be the most effective strategy for DFW.

- The small contribution of VOC emissions is greater on the days with highest 8-hour ozone in the core counties (August 16-19) indicating more influence of VOC emissions on the most stagnant days.

- The contribution of NOx emissions to 8-hour ozone in the four core counties is split about evenly between on-road mobile, point sources and area plus off-road (when all source regions are aggregated).

The average contributions to 8-hour ozone above 85 ppb in the four DFW counties were presented in Tables 4-2 to 4-4. The main findings can be summarized as follows:

- The largest emissions contributions to high 8-hour ozone in the DFW 4-county area come from nearby emissions sources.

- The relative importance of different emission source categories varies by region and year. For the 4 DFW core counties, on-road mobile sources and area plus off-road sources are the largest contributors, well ahead of point sources. For the surrounding 11 counties, these three anthropogenic source categories are more comparable with on-road mobile the largest contributor in 1999 and point sources the largest contributor in 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the 4 Counties was 36.5 ppb in 1999 and 28.6 ppb in 2010. The reduction of 7.9 ppb was due to reduced contributions from on-road mobile and point sources offset partially by an increased contribution from area plus off-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the surrounding 11 counties was 4.1 ppb in 1999 and 4.7 ppb in 2010. The 0.6 ppb increase was due mostly to higher contributions from point sources in Ellis County (0.7 ppb increase) and Kaufman County (0.3 ppb increase). The contribution of on-road sources from the surrounding 11 counties decreased from 1999 to 2010.

- The contribution to high 8-hour ozone in the DFW 4-county area from other regions within Texas and the surrounding states varied from by region and emission source category. The contributions to high 8-hour ozone decreased from 1999 to 2010 by approximately 0.1 ppb to 1 ppb per region, depending on the region.

- The contribution to high 8-hour ozone in the DFW 4-county area from other states (i.e., outside of Texas, Louisiana, Arkansas and Oklahoma) was 3.9 ppb in 1999 and 3.3 ppb in 2010.

- The contribution of model boundary conditions to high 8-hour ozone in the DFW 4-county area was about 33 ppb in both 2010 and 1999' while the contribution of model initial conditions to high 8-hour ozone in the DFW 4-county area (after two spin-up days) was less than 1 ppb in both 2010 and 1999.

The APCA results for 2010 were analyzed at monitor locations for use in conjunction with the 2010 "design value scaling." The DV scaling method as applied to DFW monitor locations was described in Section 4 and the results were presented in Figures 4-3 to 4-6 for the four hardest to control monitors (Frisco, Dallas CAMS60, Midlothian and Grapevine, see Section 3 and Figure 3-7). The results of the APCA analysis for the four hardest to control monitors can be summarized as follows:

- Dallas County is the highest contributing source area at three of the four monitors (Frisco, CAMS60 and Grapevine) while Ellis County is the highest contributing source area at the Midlothian monitor.

- Dallas County contributions are dominated by area plus off-road and on-road mobile (NOx) emissions.

- Ellis County contributions are dominated by point source (NOx) emissions.

- Transport from outside the DFW nine county area is relatively more important at Midlothian than the other three monitors.

6.0 REFERENCES

Dudhia, J. 1993. "A Non-hydrostatic Version of the Penn State/NCAR Mesoscale Model: Validation Tests and Simulation of an Atlantic Cyclone and Cold Front", *Mon. Wea. Rev*., Vol. 121. pp. 1493-1513.

Emery, C., Y. Jia, S. Kemball-Cook, G. Mansell, S. Lau, and G. Yarwood. 2004. "Modeling an August 13-22, 1999 Ozone Episode in the Dallas/Fort Worth Area" Prepared for the Texas Commission on Environmental Quality. 31 August 2004.

ENVIRON. 2004. "2007 Future Year Ozone Modeling for the Dallas/Fort Worth Area." Prepared for the Texas Commission on Environmental Quality by ENVIRON International Corporation, 101 Rowland Way, Novato, CA 94945 and Texas Engineering Experiment Station, 3000 TAMU, College Station, TX 77843. 25 August 2004.

ENVIRON. 2003a. "Meteorological Modeling. Development of Base Case Photochemical Modeling to Address 1-Hour and 8-Hour Ozone Attainment in the Dallas/Ft Worth Area." Prepared for the Texas Commission on Environmental Quality by ENVIRON International Corporation, 101 Rowland Way, Novato, CA 94945. 30 June 2003.

ENVIRON. 2003b. "Modeling a 1999 Ozone Episode in Northeast Texas" Prepared for the East Texas Council of Governments by ENVIRON International Corporation, 101 Rowland Way, Novato, CA 94945. 5 May 2003.

ENVIRON. 2002 ."User's Guide to the Comprehensive Air Quality model with extensions, version 3.10" available from www.camx.com. April.

ENVIRON. 2001. "User's Guide to the extended Emissions Processing Systems version 2 (EPS2x)." ENVIRON International Corporation, 101 Rowland Way, Novato, CA. 94945. August.

EPA. 1999. "Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS". EPA-454/R-99-004. EPA Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. May.

Guenther, A., C. Wiedinmyer, B. Baugh, S. Shepard, U. Ganesh, and G. Yarwood. 2002. "Biogenic VOC Emission Estimates for the TexAQS 2000 Emission Inventory: Estimating Emissions During Periods of Drought and Prolonged High Temperatures and Developing GloBEIS3". Prepared for Texas Natural Resource Conservation Commission, Austin, TX. April.

Mansell, G., G. Yarwood, M. Jimenez, and T. Dihn. 2003. Development of Base Case Photochemical Modeling to Address 1-Hour and 8-Hour Ozone Attainment in the Dallas/Fort Worth Area. Prepared for the TCEQ. October.

Madronich, S. 2002. The Tropospheric visible Ultra-violet (TUV) model web page. http://www.acd.ucar.edu/TUV/.

Madronich, S. 1993. "UV radiation in the natural and perturbed atmosphere", in Environmental Effects of UV (Ultraviolet) Radiation (M. Tevini, ed.), Lewis Publisher, Boca Raton, pp. 17-69.

NETAC. 2004. "Draft Clean Air Action Plan for Northeast Texas." Prepared by the Northeast Texas Air Care Technical Committee for the East Texas Council of Governments, 3800 Stone Rd., Kilgore, Texas. January.

Yarwood, G. G. Mansell, G. McGauhey, and W. Vizuete. 2001. "Biogenic Emission Inventories For Regional Modeling of 1999 Ozone Episodes In Texas". Final Report to the Texas Natural Resource Conservation Commission, Austin, TX. April.

Yarwood, G., G. Wilson, S. Shepard, and A. Guenther. 1999a. User's Guide to the Global Biosphere Emissions and Interactions System - Version 2.0. Available from http://www.globeis.com.

Yarwood, G., G. Wilson, C. Emery, and A. Guenther. 1999b. "Development of GLOBEIS - A State of the Science Biogenic Emissions Modeling System". Final Report to the Texas Natural Resource Conservation Commission, Austin, TX. Available from http://www.globeis.com.